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S I O Calcutta June 1891.

CIVIL ENGINEERING COLLEGE SEEBPORE.

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CIVIL ENGINEERING COLLEGE,

SEEBPORE.

CALENDAR FOR 1891.

Calcutta:

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1891.

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SECRETARIAT

CIVIL ENGINEERING COLLEGE, SEEBPORE, CALENDAR.

ALMANAC 1891.

JANUARY 1891.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	Th.			
2	F.			
3	S.	Christmas vacation ends.		
4	Sun.			
5	M.			
6	T.			
7	W.			
8	Th			
9	F.			
10	S.			
11	Sun.			Annual theoretical examination of 1st, 2nd and 3rd year classes begins.
12	M.			
13	T.			
14	W.			
15	Th.	Monthly fees due.		
16	F.			
17	S.			
18	Sun.			
19	M.			Admission examination begins.
20	T.			
21	W.			
22	Th.			
23	F.			Practical examination of 1st, 2nd and 3rd year classes begins.
24	S.			
25	Sun.			
26	M.	Monthly statement of fees due.		
27	T.			
28	W.			
29	Th.			
30	F.			
31	S.		Students return from survey camp.	

FEBRUARY 1891.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	Sun.			
2	M.			Session begins.
3	T.			
4	W.			
5	Th.			
6	F.			
7	S.			
8	Sun.			
9	M.			
10	T.			
11	W.			
12	Th.			
13	F.	Sree Punchomy, College holiday.		
14	S.	Ditto ditto.		
15	Sun.			
16	M.	Monthly fees due.		
17	T.			
18	W.			
19	Th.			
20	F.	Annual college sports.		
21	S.			
22	Sun.			
23	M.			
24	T.			
25	W.	Monthly statement of fees due.		
26	Th.			
27	F.			
28	S.			

MARCH 1891.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department
1	Sun.			
2	M.			Monthly examination begins.
3	T.			
4	W.			
5	Th.			
6	F.			
7	S.			
8	Sun.			
9	M.			
10	T.			
11	W.			
12	Th.			
13	F.			
14	S.			
15	Sun.			
16	M.	Monthly fees due.		
17	T.			
18	W.			
19	Th.			
20	F.			
21	S.			
22	Sun.			
23	M.			
24	T.	Monthly statement of fees due.		
25	W.	Dolejatra, College holiday.		
26	Th.	Easter holidays begin.		
27	F.			
28	S.			
29	Sun.			
30	M.	College re-opens.		
31	T.			

APRIL 1891.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	W.		1st year test examination begins.	
2	Th.			
3	F.			
4	S.			
5	Sun.			Last day of admission of students who have passed University Entrance examination. Monthly examination begins.
6	M.			
7	T.			
8	W.	Accountant examination to be advertised in *Calcutta Gazette.*		
9	Th.			
10	F.			
11	S.	Accountant examination to be advertised in *India Gazette.*		
12	Sun.			
13	M.	Detailed statement of establishment due Acknowledgment of permanent advance due. Monthly fees due.		
14	T.			
15	W.			
16	Th.			
17	F.			
18	S.			
19	Sun.			
20	M.		Last day of applications for F. E. examination.	
21	T.			
22	W.	Advertise admission to Engineer Department in *Calcutta Gazette.*		
23	Th.			
24	F.			
25	S.	Advertise admission to Engineer Department in *India Gazette.* Annual Report due.		
26	Sun.			
27	M.	Monthly statement of fees due.		
28	T.			
29	W.			
30	Th.	Last day for submitting indents for chemical apparatus.		

MAY 1891.

Date.	Day of week.	General and Office	Engineer Department.	Apprentice Department.
1	F.	Report of surveying instruments for repair due.		
2	S.	Last day for receiving applications for admission to Accountant examination.		
3	Sun.			
4	M.		F. E. examination begins.	Monthly examination begins.
5	T.			
6	W.			
7	Th.			
8	F.			
9	S.			
10	Sun.			
11	M.			
12	T.		Practical examination, 1st and 2nd year classes, begins.	
13	W.			
14	Th.			
15	F.	Monthly fees due.		
16	S.			
17	Sun.			
18	M.			
19	T.			
20	W.			
21	Th.			
22	F.			
23	S.			
24	Sun.	Queen's birthday.	Last day for receiving applications for admission.	
25	M.	Monthly statement of fees due.	Theoretical examination, 1st and 2nd year classes, begins.	
26	T.			
27	W.			
28	Th.	Indent for stationery due.		
29	F.			
30	S.			
31	Sun.			

JUNE 1891.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	M.	4th grade Accountant examination begins.	Opening of Session. New students join.	
2	T.			
3	W.			Monthly examination begins.
4	Th.			
5	F.			
6	S.			
7	Sun.			
8	M.			
9	T.			
10	W.			
11	Th.			
12	F.			
13	S.			
14	Sun.			
15	M.	Monthly fees due.		
16	T.			
17	W.	Dushohara; College holiday		
18	Th.			
19	F.			
20	S.			
21	Sun.			
22	M.		Last day of application for L.E. and B.E. examinations.	
23	T.			
24	W.			
25	Th.	Monthly statement of fees due.		
26	F.	Indent for forms due.		
27	S.			
28	Sun.			
29	M.			
30	T.			

JULY 1891.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	W.			
2	Th.			
3	F.			
4	S.			
5	Sun.			
6	M.		L.E. and E.E. examinations begin.	Monthly examination begins.
7	T.			
8	W.			
9	Th			
10	F.			
11	S.			
12	Sun.			
13	M.			
14	T.			
15	W.	Monthly fees due.		Final examination, 4th year, begins
16	Th.			
17	F.			
18	S.			
19	Sun.			
20	M.			Practical examination—1st, 2nd and 3rd years.
21	T.			
22	W.			
23	Th.			
24	F.			
25	S.			
26	Sun.			
27	M.	Monthly statement of fees due.		Final practical examination, 4th year, begins.
28	T.			
29	W.			
30	Th.			
31	F.	Budget estimate due.		

AUGUST 1891

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	S.			
2	Sun.			
3	M.			Annual theoretical examination—1st, 2nd and 3rd years.
4	T.			
5	W.			
6	Th.			
7	F.			
8	S.			
9	Sun.			
10	M.			
11	T.			
12	W.			
13	Th.			
14	F.			
15	S.	Fees for August and September due.		
16	Sun.			
17	M.	College closes for long vacation.		
18	T.			
19	W.			
20	Th.			
21	F.			
22	S.			
23	Sun.			
24	M.			
25	T.	Monthly statement of fees due.		
26	W.			
27	Th.			
28	F.			
29	S.			
30	Sun.			
31	M.			

SEPTEMBER 1891.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	T.			
2	W.			
3	Th.			
4	F.			
5	S.			
6	Sun.			
7	M.			
8	T.			
9	W.			
10	Th.			
11	F.			
12	S.			
13	Sun.			
14	M.			
15	T.			
16	W.			
17	Th.			
18	F.			
19	S.			
20	Sun.			
21	M.			
22	T.			
23	W.			
24	Th.			
25	F.	Monthly statement of fees due.		
26	S.			
27	Sun.			
28	M.			
29	T.			
30	W.			

OCTOBER 1891.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	Th.			
2	F.			
3	S.			
4	Sun.			
5	M.			
6	T.			
7	W.			
8	Th.			
9	F.			
10	S.			
11	Sun.			
12	M.		Doorga Poojah holidays.	
13	T.			
14	W.			
15	Th.			
16	F.			
17	S.			
18	Sun.			
19	M.			
20	T.			
21	W.			
22	Th.			
23	F.			
24	S.			
25	Sun.			
26	M.	Monthly statement of fees due.		
27	T.			
28	W.			
29	Th.			
30	F.			
31	S.			

NOVEMBER 1891.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	Sun.	Kali Poojah.		
2	M.	Ditto.		
3	T.			
4	W.			
5	Th.			
6	F.			
7	S.			
8	Sun.			
9	M.	College re-opens after long vacation.		
10	T.	Juggodhatree Pujah, College Holiday.		
11	W.	Ditto ditto.		
12	Th.			
13	F.			
14	S.			
15	Sun.			
16	M.	Fees for October and November due.	Surveying for 1st year begins.	Surveying begins for 1st, 2nd and 3rd years.
17	T.			
18	W.	Advertise admission examination to Apprentice Department in *Calcutta Gazette.*		
19	Th.		Surveying for 2nd year begins.	
20	F.			
21	S.	Advertise admission examination to Apprentice Department in *India Gazette.*		
22	Sun.			
23	M.			
24	T.			
25	W.			
26	Th.			
27	F.			
28	S.			
29	Sun.			
30	M.			

DECEMBER 1891.

Date	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	T.			
2	W.			
3	Th.			
4	F.			
5	S.			
6	Sun.			
7	M.			Monthly examination begins.
8	T.			
9	W.			
10	Th.		Surveying with 3rd year begins.	
11	F.			
12	S.			
13	Sun.			
14	M.		Annual tour of senior students begins.	
15	T.	Monthly fees due.		
16	W.			
17	Th.			
18	F.			
19	S.			
20	Sun.			
21	M.			
22	T.			
23	W.			
24	Th.	Christmas vacation begins.		
25	F.			
26	S.			
27	Sun.			
28	M.	Monthly statement of fees due.		
29	T.			
30	W.			
31	Th.			Last day for receiving applications for permission to appear at admission examination.

COLLEGE STAFF.

Engineer Department.

Principal	S. F. Downing, M.A., A.M.I.C.E., L.C.E.
Professor of Engineering (on furlough)	J. S. Slater.
Offg. Professor of Engineering ...	F. O. Oertel.
Professor of Mathematics	G. W. Küchler, M.A.
Teacher of Drawing (on furlough) ...	J. T. Bartlett.
Offg. ditto	Babu Dwarka Nath Dutt.
Lecturer of Physical Science ...	P. Brühl.

Apprentice Department.

Head Master and Superintendent, Christian Mess.	Vacant.
Lecturer on Physical Science ...	Babu Baroda Prosad Ghose, M.A.
Teacher	" Dwarka Nath Dutt.
Ditto (on leave)	" Surendra Kumar Bose, B.C.E.
Offg. Teacher	" Hari Churan Mookerjee, L.E.
Temporary Teacher	" Nobo Kumar Chakravarti., L.E.
Acting ditto	" Radha Roman Guho, L.C.E.

Workshops.

Executive Engineer, Calcutta Workshops Division.	J. H. Toogood, A.K.C.L.

Medical Officer.

Assistant Surgeon	Babu Dino Bandhu Dutt

CIVIL ENGINEERING COLLEGE, SEEBPORE.

ENGINEER DEPARTMENT.

GENERAL RULES.

1. The College is under the general supervision of a Board of Visitors appointed by the Government.

2. The Principal of the College is charged with the general control of the Institution, including the regulation of the course of study, the supervision of the mess and other domestic arrangements, and the maintenance of discipline; and he will from time to time issue such rules as may be necessary to secure those objects. The workshops are under the control of the Superintendent, and the students while at work in them will be under his orders, but all breaches of discipline will be reported by him to the Principal.

RULES FOR ADMISSION.

3. For admission to the Engineer Department, a student must have passed one of the following tests:—

(1) The Entrance Examination of the Calcutta University, and in English and Mathematics must have obtained at least 40 and 50 per cent. respectively of the marks allotted to those subjects. The candidate's age must be under 19 years.

(2) The F.A. Examination of the Calcutta University. The candidate's age must be under 21 years.

(3) The B.A. Examination in the B. course. The candidate's age must be under 23 years.

4. Every candidate for admission to this Department must apply in writing to the Principal not later than the 25th May, furnishing satisfactory proof of his having passed the Entrance Examination.

5. Every applicant, before admission to the College, will be examined by the College Surgeon as to his physical strength, fitness for manual labour, and eyesight. If this officer's report is unsatisfactory, the applicant will not be admitted.

6. Each student received into the College will be required to pay an admission fee of Rs. 10.

7. The session begins on the first Monday in June. All students are required to join the College on that day. Any student prevented by sickness from attending on the opening day must produce a certificate to that effect from a Civil or Assistant Surgeon, failing which he will be liable to a fine not exceeding Rs. 10. No student will be admitted or re-admitted to the College after the close of the month of June, except by special order of the Director of Public Instruction. This permission will only be given under exceptional circumstances.

Course of Instruction.

8. The course of instruction in the Engineer class will extend over five years, during the first four of which the instruction will be both theoretical and practical. The last year will be spent entirely in practical work. For details of the course of study, *see* Syllabus attached.

9. The students of the Engineer Department will be divided into sections—A, Civil; B, Mechanical.* Both sections will attend the same lectures for the first three years, and the students will then present themsevles at the first examination in Engineering of the Calcutta University, which is held in the month of May. After passing this examination the sections will separate, the students of each section attending only those lectures which will enable them to qualify at the examinations of the Calcutta University for degrees or licenses in Civil or Mechanical Engineering.

* This section has not yet been established.

10. After the expiration of one year from the date of passing the first examination in Engineering, students will be qualified to appear at the University examination for degrees or licenses.

Extract from the "Calcutta Gazette" of the 16th March 1887, page 79 Part IB.

A candidate for employment as District Engineer must be qualified in one of the manners following, that is to say, he must—

(5) Hold the degree of Bachelor of Engineering or be Licentiate of Engineering of the Calcutta University, and have been employed on engineering works for not less than five years, exclusive of any time spent on apprenticeship, and hold satisfactory certificates of good conduct and efficiency during such employment.

11. After qualifying for a University degree or license in Engineering, every student will be employed for one year on practical work only, either in the workshops or on works in progress. On completing this course to the satisfaction of the College authorities, he will be entitled to receive the final College certificate.

12 A student failing at either the first or the second University examination may, with the sanction of the Director of Public Instruction, on the recommendation of the College authorities, be permitted to attend the College for one year more in order to re-appear at the examination; but no student will be allowed to attend the College course after the expiration of five years from admission. A student failing at the second examination will be allowed to attend the practical course for one year. The final College certificate shall state whether the student has or has not taken the University degree in Engineering, and in which branch, and whether he has or has not completed the course of practical work to the satisfaction of the College authorities. A College certificate gives the holder no claim to a Government appointment.

13. Students will attend daily in the class-room and in the workshops in accordance with the College time-table. The hours of

work may vary with the seasons of the year. The fourth-year class is excused from work in the shops.

14. There will be a long vacation from about the middle of August to the end of October. Every student must leave the College during this vacation, and parents or guardians must satisfy the Principal, before their sons or wards can be admitted, that they are able to conform to this rule. The period from the middle of November to the end of January will be occupied in survey work.

Tuition Fees.

15. The tuition-fee for students of the Engineer class is Rs. 8 a month for each month of the year, vacation included.

Scholarships.

16. For the present, one junior scholarship of the value of Rs. 20 a month, three of Rs. 15 a month, and six of Rs. 10, tenable for two years, will be given annually to students entering the first-year Engineer class who do not already hold University scholarships. The scholarships will be awarded by the Director of Public Instruction on the last day of June to the following classes of students in order:—(1) B.As. who have taken up the B. course; (2) F.A. candidates;* (3) Entrance candidates according to the number of marks gained in English and Mathematics jointly.

17. Senior scholarships of the same number and value will be competed for at the annual examination held in May for the promotion of students from the second to the third-year class.

18. The number of College scholarships awarded, whether junior or senior, will in no case exceed one-half of the number of candidates for them.

19. Two scholarships of Rs. 10 a month each, tenable for one year, called Forbes' scholarships, will be awarded on the result of the first examination in Engineering of the Calcutta University. A Forbes' scholar, unless he also holds a College scholarship, will be exempted from paying the tuition-fee of Rs. 8 a month.

20. On the result of the University Examination for degrees and licenses, two graduate scholarships of Rs. 100 each and six of Rs. 50 each will, for the present, be awarded to those students who pass the best examination. The scholarships of Rs. 100 a month will be reserved for holders of the B.E. degree, *i.e.*, those who have passed the F.A. examination. All the eight scholarships will be tenable for one year, provided that the students are continuously employed during that period in practical work under the supervision of the Public Works Department, and to the satisfaction of those under whose orders they may be placed.

21. A gold medal will be awarded to the student who gains the highest marks in mathematics at the examination for the B.E. degree. The holder of this medal will be styled the "Ambica Churn Chaudhuri Medalist."

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* Except those who passed in the 3rd Division.

SCHOLARSHIPS.

22. All scholarships will be liable to forfeiture in case of misconduct or of neglect of work in class or in the field; or of failure to pass any prescribed examination.

STANDING ORDERS FOR STUDENTS.

23. Except with the special sanction of the Principal, students of the Engineer Department will be required to reside on the College premises, so far as the accommodation will permit, at a rent to be fixed from time to time by the Government. The present rate is Rs. 2 a month for both European and native students.* This charge will be levied all the year round except during any period in which the student may be in camp

24. Each resident student must provide his own clothing and bedding and a camp bedstead. No furniture may be brought into the College without special permission.

European Mess.

25. Every resident European student will join the European mess. A charge of Rs. 20 a month will be made to defray the cost of messing. During the vacation, reckoned at 2½ months, each European student will be required to pay monthly, in addition to Rs. 2 for house-rent, a contribution of Rs. 2 towards the cost of maintaining mess-servants.†

26. On joining the mess, every student will pay an entrance fee of Rs. 10 to the mess fund to provide for the cost of crockery, knives and forks, table-linen, &c. A list of breakages and other damage done will be prepared monthly, and each student will be required to pay, by the 15th of the following month, an equal share of the cost. On leaving the mess, if a student has paid all demands, his entrance fee will be returned to him; otherwise it will be forfeited to the mess fund.

27. For students joining the European mess, the following table shows the annual cost of living at the College, the term being reckoned as nine months and-a-half and the vacation as two months and-a-half of the year:—

	Tuition per mensem.	Board per mensem.	House-rent per mensem.	Total monthly charges.	Total per annum.	Grand total.
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
Term	8	20	2	30	285	315
Vacation	8	2	2	12	30	

Native Mess.

28. Hindu students residing on the College premises must ordinarily join the College mess for natives, and must abide by the

* Native students now in the College and paying Re. 1 a month house-rent will continue to pay this sum only.

† European students have, at their own request, established a private mess, the cost of which is about Rs. 30 per mensem.

rules sanctioned by the Principal for the management of their mess. Each student on joining the mess will be required to deposit "caution-money" to the amount of Rs. 5, which will be ultimately returned to the student if he has not rendered himself liable to the forfeiture of the whole or any part of it.

29. A charge of Rs. 7 a month will be made to those joining the native mess. During the vacation of two months, every member of the mess will be required to pay monthly, in addition to Rs. 2 for house-rent, a contribution of Re. 1 for mess-servants.

30. For students joining the native mess, the following table shows the annual cost of living at the College, the term being reckoned as nine months and-a-half and the vacation as two months and-a-half of the year:—

	Tuition per mensem.	Board per mensem.	House-rent per mensem.	Total monthly charges.	Total per annum.	Grand total.
	Rs.	Rs.	Rs.	Rs.	Rs. A.	Rs.
Term	8	7	2	17	161 8	189
Vacation	8	1	2	11	27 8	

31. All payments, whether on account of tuition-fees, messing or house-rent, must be made into the Principal's office on or before the 15th of the month for which the money is due, after which dath no payment will be taken unless accompanied by a fine of Re. 1 for every three days of delay. If the payment is not made during the month for which it is due, the defaulting student's name will be struck off the College books, and he will not be re-admitted until he has paid all arrears with fines and the usual re-admission fee.

32. The monthly charge for messing may, if necessary, be altered from time to time in reference to the prices of provisions.

33. All breaches of discipline committed by any student of the College will be reported to the Principal, who will dispose of them according to the rules and practice of the Education Department.

34. A Conduct Register of each student in the College will be kept by the Principal. The Principal has no power to cancel or alter an entry once made and signed.

35. Students are liable to have their names placed in the Conduct Register as defaulters for the following offences:—

(I) Disobedience of orders.
(II) Absence without leave.
(III) Idleness.
(IV) Insubordination or disrespect to the College or Workshop authorities.

36. Students may be removed from the College for habitual or gross misconduct, for continued idleness or neglect of work, or for frequent entry in the Conduct Register. Every such removal shall be reported to the Director of Public Instruction, and any fees paid by the student shall be forfeited.

37. Every student will be responsible for any machines, tools or other articles that may be placed in his charge. He must produce them when called upon to do so, and must at once report any damage done to them. In case of loss or damage arising from carelessness, he may be called upon to pay the cost.

38. A certain number of the students will be appointed monitors, whose duty it will be to assist the College authorities in the maintenance of discipline. For the performance of this duty, each monitor will receive a small sum monthly. Any monitor may be removed by the Principal for misconduct, or for inefficiency in the discharge of his duties.

39. No resident student will ordinarily be allowed to keep a private servant. This permission may be given under exceptional circumstances, but any servant so employed will be under the orders of the Principal.

40. On Sundays all resident Christian students, Protestant or Roman Catholic, will be required to attend the services held in their respective chapels.

41. All students will be required, while in the workshop, to wear a uniform dress, which will be supplied to them at cost price.

42. Leave will be granted by the Principal only. No leave will be granted except on a written application.

43. No resident student may leave the College premises without the written order of the Principal, whether on special leave or on a general holiday.

44. European students will be encouraged to join the Volunteer Corps. Those who join it will be allowed such occasional leave as may be required by the regulations relating to volunteers

45. One and two appointments in alternate years are now guaranteed to students of the College. The selected men are posted as Apprentice or Assistant Engineers in the Public Works Department.

46. All students are obliged to join the College Athletic Club the subscription to which is Re. 1-8 per annum and the entrance fee Re. 1.

ENGINEER DEPARTMENT.

SYLLABUS OF INSTRUCTION.

1.—MATERIALS OF CONSTRUCTION.

CLASSIFICATION ... (a) Stone, brick, tiles, terra-cotta, timber, metals.
(b) Limes, cements, mortars, concretes, plasters.
(c) Mastics, glue, paints.

STONE.

Characteristics of Building Stone.—Durability dependent on atmospheric influence and physical structure. Facility of working; hardness; strength; weight; appearance; position in quarry; seasoning; natural bed; agents which destroy stone.

Examination of stone.—Fracture. Tests:—crushing; absorption; Brard's test; acid test; Smith's test. Practical way of ascertaining weathering qualities.

Classification of stone. Scientific.—Siliceous; argillaceous, and calcareous; *Practical.*—Granites and other igneous rocks; slates; sandstones; limestones.

Granite.—Common granite. Syenite and syenitic granite; quarrying and dressing: uses to which granite is applied.

Igneous rocks other than granite.—Porphyry, gneiss, mica schist, hornblende schist, trap, basalt.

Slates.—Cleavage; plerry, quarrying, hardness, toughness, grain, veins objectionable, pyrites. Tests.

Sandstones.—Composition, colour. Practical classification. Fracture a test of quality. Weight and absorption.

Limestones.—Composition, texture, marbles, compact limestones, granular limestones, shelly limestones, dolomite.

Artificial stone.—Ransome's, Sorel's, Victoria stone, Garlick stone.

Preservation of stone.—Bituminous matter, drying oil, silicate of potash, silicate of lime.

Quarrying.—Mode of conducting quarrying operations in India. Blasting.

BRICKS, TILES AND TERRA-COTTA.

Brick-earths.—Effect of the following ingredients in brick-earths:—Alumina, silica, lime, carbonaceous matter, alkalies, salt, oxide of iron, reh.

Practical classification—Strong clays; loams, marls, malm.

Composition of a good brick-earth. Colour of bricks.

Brick-making—Preparation of brick-earth:—Unsoiling, digging and weathering, grinding, washing, tempering.

Moulding.—Slop moulding, sand moulding, pallet moulding, frog, form of mould, and size of brick.

Drying.—In sheds, out of doors, hacking, scintling.

Burning.—In clamps, in kilns, amount of fuel required, comparative advantages of clamp and kiln burning, Hoffmann's kiln, Bull's kilns.

Characteristics of good bricks.—Freedom from flaws, shape, absorption, texture.

Tests for bricks.—Fractured surface, Brard's test.

Fire-clay.—Uses, where found, composition.

Tiles.—Preparation of clay moulding pot, and flat tiles, various forms of tiles in use in India.

Terra-cotta.—Nature of clay, preparation of clay, moulding, glazing, burning.

LIMES, CEMENTS, MORTARS, CONCRETES, PLASTERS.

Constituents of limestone that do not produce hydraulicity.—Carbonate of lime, sand.

Constituents that produce hydraulicity.—Clay, soluble silica, carbonate of magnesia, alkalies, sulphates.

Classification of limes and cements.—Fat limes, poor limes, hydraulic limes, cements.

Varieties of lime in common use.—Fat limes, grey chalk, lias, carboniferous, magnesian; limestones used in India; kunkur.

Artificial hydraulic lime. Natural cements—Carbonate of magnesia, cement stones.

Roman cement.—Weight, strength, storing, uses. Medina and Atkinson's cements.

Artificial cements. Portland cement.—Manufacture from chalk and clay. Manufacture from limestones and shale. Tests of quality. Rough tests. Storing.

Strength when mixed with sand. *Scott's cement. Selenitic cement. Pasley's cement.*

Lime and cement burning.—Forms of kilns. Flare and tunnel kilns. *General rules for burning*—Heat gradually applied, temperature, size of lumps, quantity of fuel, appearance of stone while burning Overburnt and underburnt cements. Dead-burnt lime.

Sand.— Pit sand, river sand, sea sand, screening and washing sand. Examination of sand.

Pozzuolanas.—Natural and artificial pozzuolanas

Mortar.—Ordinary mortar, cement mortar. Evils of fat limes. Hydraulic limes. Cements. Description of sand to be used in mortar.

Water.—Salt water, dirty water.

Preparation, and mixing mortar.

Slaking lime—Quantity, time. Ground lime. Water.

Mixing.—Methods, quantities; bulk of mortar produced.

Precautions in using mortar.

Concrete.—The matrix. The aggregate; shape, size. Aggregates in common use:—Broken brick. Burnt clay. Gravel. Ballast Slag. Voids. *Proportion of ingredients. Mixing*:—Materials all mixed together: mixed separately. Relative advantages of the two methods.

Laying concrete:—In trenches. Under water. *Bulk of concrete produced. Expansion of concrete. Uses of concrete.* Coignet's Béton. *Strength of concrete. Monolithic structures in concrete.*

On the action of foreign constituents in limestones and cements. Fat limes:—Calcination. Slaking. Setting. Mortar. Action of sand. *Hydraulic limes and cements containing clay.*—Clay. Lime. Calcination. Proportion of clay. Effect in cements burnt at a moderate temperature. Effect in cements burnt at a high temperature. Composition of clay. Effects caused by different degrees of calcination. Hydraulic limestones. Cement stones containing a small proportion of clay. Cement stones containing a large proportion of clay. Slaking. Setting. Proportion of clay. Pozzuolana. Carbonate of magnesia. Sulphates.

Plasters:—Lime and cement plaster. Gypsum. Plaster of Paris. Stucco.

Asphaltes:—Characteristics of good asphalte. Methods of laying. Uses.

White-wash.

Paints and Varnishes.

Paints. Distemper. Varnish. Mastics. Glazing. Papering.

Timber.

Growth of trees.—Annual rings, medullary rays, sapwood, heartwood, felling, squaring.

Characteristics of good Timber.

Defects in timber.—Heartshakes, starshakes, cupshakes; rind galls, upsets, foxiness, twisted fibres.

Classification of timber.—Pine wood or soft wood, leaf wood or hard wood.

Seasoning timber.—Natural seasoning, water seasoning, boiling and steaming, hot air seasoning, smoke-drying, scorching and charring.

Causes of decay in timber.—Continued dryness; continued moisture; alternate dryness and moisture; continued moisture with heat. Dry rot. Positions in which dry rot occurs. Detection of dry rot, checking dry rot. Wet rot. Positions in which wet rot occurs.

Destruction of timber by insects.—Destruction by marine animals and whiteants, and modes of protecting timber from their attacks.

Preservation of timber.—By good ventilation and obviating moisture. By the use of oil paint. By the application of tar boiled with powdered chalk. Bethell's process of creosoting. Boucherie's process of injecting sulphate of copper. Margary's process. Payne's process.

Measurement of timber.

Metals.

Iron ores.—Blackband. Red and brown hœmatite, magnetic, spathic, argillaceous.

Preparation of ores.—By washing. By roasting in clamps and in kilns.

Smelting.—Description of blast furnace. Hot blast. Cold blast. Flux, slag. Comparative advantages of hot and cold blast iron.

Pig iron.—Foreign substances in pig iron Carbon in a state of mechanical mixture and in chemical combination with cast iron. Effects of the following impurities upon cast iron, wrought iron and steel:—Silicon, phosphorus, manganese, sulphur.

Cast iron.—Remelting pig iron. Grey and white cast iron, mottled cast iron. To distinguish grey from white. Chilled iron. Malleable cast iron. Toughened cast iron. Descriptions of pig iron for casting in sand. Pattern. Cold shut, core, head, casting pipes, examination of castings, cast iron pipes, tests for cast iron.

Production of Wrought Iron.

Effect on pig iron of.—Refining, puddling, shingling, rolling: contraction of wrought iron, defects in wrought iron, cold-short, hot-short, or red-short. Mitis castings.

Tests for wrought iron.—Tensile strength. Ductility. Methods of testing. Tensile tests, forge tests, testing rivets, appearance of fractured surface.

Market forms of wrought iron.

Production of Steel.—Amount of carbon in steel. Characteristics: —hardening, tempering. Varieties of steel; blister steel; spring steel; shear steel; cast steel; Bessemer process; Siemens-Martin process; Basic process.

Hardening and tempering steel.—Table of temperatures and colours. Degree of heat for hardening and methods of cooling. Hardening and tempering in oil.

Case hardening.

To distinguish steel from wrought iron. Testing steel.

Forging iron.—The form to be given to forgings, overheating.

Forging steel.—Shear, blister and cast steel.

Welding.—Wrought iron, steel.

Preservation of iron.—Corrosion, galvanising, painting, Dr. Angus Smith's process for cast iron pipes, Barff's process, Bright iron work.

2.—CONSTRUCTION.

Brick-Laying.

General principles of brickwork. Bond.

Operations of brick-laying. Bond timber objectionable. Mortar joints. Fine joints. Lime putty.

Precautions against settlement. Joining new work to old. String courses and copes. Stone quoins.

Scaffolding.

Masonry.

General principles of stone masonry. Ashlar. Block in course. Coursed rubble. Common rubble. Rubble backing. Strength of a mass of masonry as depending on the size of stones, the bond, and accuracy in dressing. Bonding—headers and stretchers; through bonds.

Quoins. Direction of beds in battering walls String courses and copes. Pointing. Drystone masonry. Mechanism for moving large stones.

Instruments used in building. Scaffolding.

EARTHWORK.

Preliminary arrangements to be undertaken by the Engineer. Preparation of plan and sections. Practical stability of earthwork. Of excavation in rocks.

Setting out of earthwork. Base or formation level. Sides or slopes. Half breadths. Computation of volume of a piece of earthwork. Simpson's rule for volumes. Prismoidal formula. Use of tables in such computations. Setting out. Angles. Centre line. Side widths; on side long ground. Use of the bevil plumb rule, clinometer, mason's level, and boning staves.

Execution of earthwork. The tools and implements used. Size and form of barrows. Distribution of labour. Dobbin carts. Earth wagons. Boring to ascertain nature of ground.

Cuttings. Equalisation of cuttings and embankments. Side cuttings. Spoil banks. Stripping the soil. The consecutive operations in forming a heavy cutting. The horse run with large barrows. Casting up by stages. Slips. Drainage.

Embanking and puddling. Preferable materials for embankments. Embankments formed in one layer. In two or more thick layers. Settlement of embankments. Side slopes, facing slopes. Embanking in side-long ground. Foundations of embankments. Punning. Trimming slopes.

CARPENTRY.

Joints and Fastenings.

Joints.—Lapping, fishing, scarfing. Different forms of scarf. Halving. Dovetails. Notching. Cogging. Mortise and tenon joint. Chase mortises. Circular joints. Bridle joints. Post and beam joints. Strut and beam joints. Tie and brace joints. Suspending pieces. Wedging. Fox-wedging. Keys.

Fastenings. Pinning:—Nails, spikes, trenails, screws. Bolts, washers, plates. *Straps:*—Heel straps, branched straps. Cast-iron shoes and sockets. Tie-beam plates Shoe for foot of rafters. Double shoe. Socket pieces. Protection of iron fastenings from decay.

Built beams and ribs of timber. Trussed beams of timber.

Floors.—Single floors, double floors, framed floors; wall plates, templates. Common joists, strutting joists, trimming joists. Floor boards. Ceiling joists. Precautions to be observed in laying floors, with respect to door and window openings and partition walls.

Partitions.—General remarks. Framed without doorway. With ordinary doorway in centre. With side door. Common partition. Brick-nogged partitions.

Timber Roofs.—Flat roof. Pitch of roof. Couple roof. Couple-close roof. Collar beam roof. King bolt roof without struts. King post roof. Queen post roof. Purlins. Rafters.

Stairs.—Dimensions of stairs. Rule for proportion of rise to tread. Method of laying out stairs. *Different forms of stairs*:—Straight, dogged-legged, geometrical. *Parts of wooden stairs*:—Strings, steps. General rules for planning stairs.

Doors and windows.—Ledged doors, ledged and braced doors, panelled doors, glazed doors. Door frames. Fixed sashes Fanlights. Sashes hung on centres. General arrangements of sliding sashes

Foundations.

Importance of slight and uniform settlement. Various modes of attaining that object. Action of water on foundations Various conditions dependent on nature of bearing strata.

Importance of ascertaining the character of bearing strata. Trial pits. Borings.

Dry foundations Rock. Gravel Sand. Mixed strata of rocks and clay. Shale. Clay. Expansion of clay when exposed. Bearing stratum underlying soft ground of considerable depth. Crust of good ground overlying soft substratum.

Mechanical construction of foundations. Footings. Planking. Use of sand, concrete and béton.

Land foundations on artificial bottom. Consolidation of soft ground by driving piles. Platforms of fascines, timber or concrete, forming floating foundations.

Foundations on good natural bottom under water. Piled foundations. Timber piling. Cast and wrought iron piling. Iron screw piles. Hollow cast iron cylinders. Brick wells, as employed in India. Sand pump. Solid foundations laid under water. Pierre perdue. Random blocks of béton Béton laid in caissons lined with tarpaulin. Solid masonry built on the natural bottom by divers. Solid masonry in cribs.

Foundations on sites where the water can be temporarily excluded. Solid masonry sunk in caissons on a bottom dredged out and levelled with béton. The same on a piled bottom. Solid masonry built in a cofferdam.

Arching.

Names of parts—Different forms of arches. Inverted arches.

Brick arches.—Rough brick arches, axed arches, gauged arches.

Arches, over openings in wall.—Segmental face arch, semi-circular arch, straight arch

Stone arches—Ashlar. Rubble.

Buildings.

Selection of site—Design of foundations and preparation of bed. Thickness of walls. Points to be attended to in building walls. Buttresses. Arches in walls. Floors of various kinds. *Roofs*—Different forms of trusses in wood and iron. *Roof coverings*—Various materials used for this purpose, and mode of applying. Ceilings, chimneys, fire-places. Doors and windows. Drainage and ventilation, lightning-conductors.

Bridges.

Temporary expedients for crossing rivers.—Causeways, temporary bridges, ferry boats, boat and pontoon bridges, rope bridges.

Masonry Bridges.—Details of the various parts in brick and stone, with principles of design.

Wooden Bridges.—Various forms of trusses and details of parts.

Iron and Steel Bridges.—Different forms of girders used, with full details of joints, roadway, &c., and mode of calculating the strength of the various parts. Methods adopted for erecting bridges.

Roads.

Fairweather roads in districts liable to inundations. Permanent roads. Resistance of vehicles on roads variously paved. Ruling gradients. Staking out the centre line. Formation. Breadth and cross section. Earthwork. Side slopes. Culverts and drains. Road metalling. Paving with stone blocks. Maintenance and repairs. Hill roads. Street paving in towns.

Railways.

Survey and choice of line. Gradients and curves. Resistance of railway trains on a level straight line. On curves and steep gradients.

Formation of roadway. Earthworks. Formation level. Base. Culverts. Regulations about bridges. Level crossings. Fencing. Mile posts. Gradient posts.

Permanent-way of railways. Gauge of railways. Ballast. Timber sleepers. Rails. Chairs. Rail joints, fish joints. Cast-iron sleepers. Wrought-iron sleepers. Cant of rails. Elevation of outer rail on curves. Sidings. Switches and crossings. Turntables.

Railway stations. Design and arrangement. Classification. Terminal stations. Intermediate stations Selection of site. Details of terminal stations. Approaches, roads and yards. Position of principal buildings. Parallel or side-station system. Transverse or end-station system. Goods stations. Goods yard at small stations. Signals.

Irrigation Works.

Well-irrigation.—Common machinery employed in India for raising water from wells.

Canal irrigation. Inundation canals.—General rules for the selection of best site for head works. Head sluices. Slope of bed.

Permanent canals.—Sources of supply, amount of water required, slope of bed, discharges of canals, section of channel, alignment of canal. Head works—weirs, regulators; falls, rapids, locks, navigation channels, aqueducts, inlets, level crossings, super-passages.

Distribution of water.—Rajbahas. Modules.

Tank-irrigation.—Site of embankment. Different forms of embankment Waste weirs. Irrigation sluices.

River inundation and river improvement.—General methods in use to improve the course of streams, and to render channels navigable.

3.—ESTIMATING.

General principles of estimating. Rules of mensuration of surfaces and solids.

The student will be exercised in taking out quantities and framing an estimate from working drawings of the following examples:—

A masonry culvert. A portion of road in cutting and embankment. A house. A wooden bridge. An iron bridge. A masonry bridge.

4.—APPLIED MECHANICS.

Definitions.

Elasticity.—Plasticity and rigidity. Stress, its nature and intensity. Tensile, compressive, and shearing stresses. Positive and negative senses of a stress. Stresses of uniform and variable intensities. Ultimate strength. Factor of safety.

Tension.

Simple tension.—Work done in stretching a rod. Thin pipes under internal fluid pressure. Strength of prismatic solids under tensile stress when the resultant of applied forces does not coincide with the axis of the solid. Safe tensile co-efficients of various materials.

Compression.

Classification of bars or pillars under compression:—Very short pillars, short pillars, long pillars, very long pillars. Methods of failure of these classes of pillars. Rondolet's, Hodgkinson's and Gordon's formulæ. Euler's formula. Fairbairn's formula for collapsing of tubes under fluid pressure. General remarks on the applicability of the above formulæ. Safe compressive co-efficients of materials usually subjected to a compressive stress: impact, pile driving.

Transverse Strain.

Proof that the stress at each point varies as its distance from the neutral axis.

Determination of the position of the neutral axis.

Determination of the moment of resistance.

Calculation of moments of inertia of ordinary sections used in engineering construction.

Flanged girders:—Approximate and accurate methods.

Proportion of I beams for equal strength.

Beams of uniform strength.

Bending moments and shearing forces.—(Treated graphically and analytically).

Cantilever under single load at free end.

Cantilever under uniformly distributed load.

Cantilever under uniformly distributed load, and one or more detached loads.

Beams supported at the ends and loaded with detached loads at any point.

Beams supported at the ends and loaded uniformly.

Beams supported at the ends and loaded uniformly, and also with one or more detached loads.

Beams supported at the ends and loaded with a single detached moving load.

Beams supported at the ends, supporting an uniformly distributed moving load of length less than the span.

Beams supported at the ends, supporting an uniformly distributed moving load of length greater than the span.

Beams supported at the ends and loaded at intermediate points.—Conversion of detached loads into equivalent uniformly distributed load.

Statics of Structures.

Framework loaded at the joints.

Triangular frames.—Diagram of forces for a simple triangular frame Triangular trusses. Cranes and derricks. Sheer-legs and tripods. Effect of the tension of the chain in cranes.

Incomplete frames. Preliminary ideas. Simple trapezoidal or Queen post truss. General case of a funicular polygon under a vertical load. Suspension chains.

Compound frames.—Compound triangular frames for bridge trusses. Roof trusses in timber. Queen truss for large iron roofs. Diagram of forces in general.

Framework girders.—Warren girders under various loads. N trusses.

Girders with redundant bars—Lattice girders, flanged beams.

Deflection of Beams.

Deflection due to the maximum bending moment. General equation of deflection curve. Elementary cases of deflection and slope. Beams propped in the middle. Stiffness of beams. Stiffest beam that can be cut from a circular log.

Shearing.

Distinction between tangential stress and normal stress. Equality of tangential stress on planes at right angles. Tangential stress equivalent to a pair of equal and opposite normal stresses. Web of a beam of I section. Method of computing the intensity of the shearing stress at any point in a bent solid.

Resistance of Prismatic Solids to Simple Torsion.

Explanation of the phenomena of simple torsion

A circular section, solid or hollow, most favourable form of prismatic solid for resistance to torsion.

Twisting moment. The limiting intensity of the resistance to torsion is that of the shearing stress.

Investigation of the resistance of a circular prism to torsion round its mean fibre.

The strength of axles subject to simple torsion. Values of the limiting intensity of working resistance to simple torsion for different materials

Diameter of a shaft to transmit a given power.

Blockwork structures.

Stability at a plane joint. Stability of a series of blocks Centres of pressure or resistance. Line, polygon and curve of pressures Line of resistance, or polygon of centres of pressures. Moment of stability.

Retaining walls—Theory of earth pressure. Angle of repose of different soils. Walls supporting a bank of earth with horizontal surface. Surcharged walls. Graphic methods of solution. Determination of the centre of pressure on any joint of a wall supporting a load of earth at its back. Maximum intensity of stress at any joint in a retaining wall. Minimum intensity of pressure. Tensile stress at a joint. Effect of cohesion of mortar. Connection between maximum intensity of pressure on foundation course and power of resistance of earth foundation. Methods of equalising intensity of stress on foundation courses.

Masonry arches.—Definitions. Curve of pressures and line of resistance. Conditions of stability. Treatment of the weight of loads of different densities Graphic process of determining the stability and resistance of any proposed arch by drawing the line of resistance. Depth of key-stone.

Stability and resistance of abutments and piers—Graphic process of determining the position of resultant pressure on any joint of an abutment. Design of piers.

Stability of foundations of structures in masonry and brickwork.

5.—HYDRAULICS.

1. General Principles.

Velocity and volume of flow. Principle of continuity. Flow in a stream. Steady and varying motion of streams. Fluid acting on piston. Theorem of Bernouilli. Hydraulic head.

2. The flow of Liquids through orifices.

Application of the theorem of Bernouilli. Velocity of flow due to given head. Co-efficient of velocity. Co-efficient of contraction. Co-efficient of discharge. Co-efficient of resistance. Connection between co-efficients of velocity and resistance Discharge from large rectangular orifices. Borda's mouth-piece. Co-efficient of contraction for Borda's mouth-piece obtained theoretically. Incomplete contraction. Cylindrical and conical mouth-pieces. Flow over notches. Triangular

notches. Velocity of approach. Application of results to measurement of flow in streams. Francis' formula. Discharge of measured quantities of water for irrigation purposes. Italian and Spanish modules Other forms of apparatus answering the same purpose Discharge under varying head. Jet pump. Separating weirs.

3. The flow of Liquids in Pipes.

Laws of friction between liquids and surfaces. Froudes' and Unwin's experiments. Loss of head due to friction in pipes. Hydraulic mean depth. Variation of co-efficient with velocity and diameter. Darcy's formula. Hydraulic gradient. Ordinary computations of size of pipes and volume of discharge. Loss of head due to bends, elbows, enlargements, &c.

4. Movements of Water in Canals and Rivers.

Mean velocity corresponding to given gradient. Variation of the co-efficient. Velocity at different parts of the section of the stream. Mean velocity in terms of surface and bottom velocity. Ratio of mean to maximum velocity. Forms of section of channel, circular, trapezoidal, egg-profile. Most economical section of channel with given side-slopes Form of section for a constant velocity with varying discharge.

5. Impulse and Reaction of Water.

Pressure of a jet on a plane surface fixed or moving. Energy communicated to the moving surface and efficiency of jet. Velocity of surface for maximum efficiency. Resultant pressure on curved surface, direct impulse and reaction. Condition to avoid loss by shock when jet is received. Condition for least loss of kinetic energy when jet is discharged.

6. Hydraulic Machines.

Transmission of energy by hydraulic pressure Power of hydraulic motors Causes of loss of efficiency in water pressure engines, pumps, accumulators, and water-wheels.

Principle of momentum as applied to rotating machines; turning couple equal to the change of moment of momentum.

Speed for maximum efficiency and losses in reaction wheels.

Most efficient speed of turbines. Angles of moving and guiding vanes Forms of vanes. Losses of efficiency. Regulation of power of turbines. Estimation and graphical representation of the diminution of total and pressure-head in flow through a turbine.

Centrifugal pumps with radial vanes. Speed for given lift with given efficiency. Utilisation of kinetic energy of whirl. Best form and dimensions of spiral chamber. Whirlpool chamber. Centrifugal pump with backward curved vanes. Losses. Volume discharged.

Efficiency of propellers. Jet propellers. Paddle wheel. Screw.

6.—MECHANICAL ENGINEERING.

Description and Construction of the Elementary Pieces of Machines.

Shafting. Couplings. Clutches. Friction clutches. Plummer blocks or pedestals. Fixings, wall boxes, brackets, hangers. Footsteps. Bolts and nuts.

Tooth gearing. Spur wheels. Racks. Bevil wheels. Worm gearing. Modes of fixing wheels upon shafts.

Driving belts. Drums and pulleys. Fixing drums and pulleys upon shafts. Rope transmission. Telodynamic transmission.

Cranks. Eccentrics. Cams. Connecting rods.

Valves. Pistons. Stuffing boxes.

Steam Engine.

Fuel and combustion.—Chemical composition and physical properties of the different kinds of fuel. Calorific value of some elements, and their compounds. Determination of the calorific value of the different kinds of fuel. Process of combustion. Formation of smoke and flame. Losses by incomplete combustion. Air necessary for combustion. Temperature of combustion. Density of burnt gas. Maintenance of draught, by convection; by artificial means. Transmission of heat from furnace gases. Waste of heat. Methods of stoking. Mechanical stokers.

The Boiler.—Types of boilers. Proportions to provide sufficient grate and heating surfaces. Proportions and methods of construction to provide sufficient strength. Construction to facilitate cleaning and examination. Boiler fittings.

The Steam Engine in general.—Types of engines. Horse-power. Relations between dimensions of cylinder, speed of piston or revolution, and power of engine. The design of the principal details of an engine. Piston, piston rod, connecting rod, crank shaft. The slide valve and eccentric. Link motions. Expansion valves. Zeuner's valve diagrams. The Indicator and Indicator diagrams. The condenser and air pump.

The Locomotive Engine.—Train resistance. Tractive power. Adhesion. Express and coupled engines. General description of ordinary engines. Goods engines. Limit of load on wheels. Fatigue of rails. Description of engines for exceptional circumstances. Engines for steep inclines. Engines for exceptionally heavy trains on moderate inclines. Engines for narrow gauge lines. Double traction. Fairlie engines.

General arrangements of engine and boiler. Reversing. Expansive working. Webb's compound engine. Brakes. Framing. Axle boxes. Springs. Axles. Wheels. Effect of curves on wear of tires. Provisions for reducing the effect of sharp curves. The tender. Ramsbottom's scoop.

Thermodynamics.

Measurement of temperature and quantities of heat. Relations between pressure, temperature, and volume of steam. Total heat of formation of steam.

External work done during evaporation. Relation between heat and work; Joule's equivalent. Internal work of evaporation.

Operation of a non-expansive working engine. Expenditure of heat and steam. Efficiency. Condensation water.

Calculation and graphical representation of the energy exerted by an expanding fluid. Relation between pressure and volume of expanding steam. Indicator diagram. Mean pressure.

Transmission of heat to and from metal of cylinder when steam is used expansively, and consequent limitation of economical ratio of expansion. Expenditure of heat and steam in expansive working engine. Efficiency. Advantage of steam jacket and superheating. Operation of compound engine. Indicator diagrams. Advantages of compound engine.

Efficiency of thermally perfect air engine. Reversibility. Carnot's principle. Maximum efficiency of any heat engine.

7.—SURVEYING.

Lecture Room Course.

(1) Construction of Scales—Simple, diagonal, and vernier.

(2) Useful problems in surveying.—To avoid obstacles in the chain line—

1st—When the obstacles can be seen over and chained round, but not across.

2nd.—When it can neither be seen over nor chained across, but can be chained round.

3rd.—When it can be seen over, but neither chained over nor round.

(3) To find the intersection of two lines meeting in a lake or river, and the distance to the point of meeting.

(4) To find your place in a survey by observation from that position to certain fixed points on the survey—

1st.—With prismatic compass.

2nd.—With pocket sextant.

(5) Investigation of various methods of tracing curves—

(*a*) Without angular instruments—

By chords and offsets.

By offsets from a common tangent.

By successive bisection of arcs.

(*b*) With theodolite—

By angles at the circumference when the point of intersection of the tangents to the curve is accessible.

When the point of intersection is inaccessible.

By two theodolites at starting points of curve

(*c*) Serpentine curves.

(6) Plotting chain survey.
(7) Plotting survey with chain and prismatic compass.
(8) Plotting theodolite traverse by Gale's method.
(9) Plotting level sections.
(10) Computation for the reduction of the base line.
(11) Reduction to the centre of angles taken from satellite stations.
(12) Calculation of the sides of the trianglesin a trigonometrical survey.
(13) Calculation of the relative vertical heights of the stations as determined by theodolite.
(14) Equalizing areas—
  (*a*) Of irregular polygons.
  (*b*) Of irregular offsets.
(15) Colouring of maps and surveys with the necessary printing of title and drawing of scales.
(16) Colouring of level-sections.
(17) Enlargement or reduction of plans by—
  (*a*) Pantograph.
  (*b*) Squares.
(18) Methods of entering the topographical details, horizontal and vertical styles.
(19) Conventional signs used in surveys and plans.

Practical Astronomy.

(1) Astronomical definitions.
(2) Determination of the true meridian—
  By equal altitudes of a star.
  By maximum elongation of a circumpolar star.
(3) Determination of latitude—
  By meridian altitude of the sun with sextant and artificial horizon.
  By circummeridian altitudes of a star with theodolite
  By observations on polaris.
(4) Approximate methods of determining the meridian and latitude without the use of angular instruments.
(5) Construction of horizontal sun-dials and method of graduating dial-plate.
(6) Simple methods of determining the longitude in which the use of the nautical almanac is not required.

Field Work.

First-year Class.

A small survey with chain only.

A more extensive survey (Botanic Gardens) with chain and prismatic compass.

A line of levels about two miles long, the same to be carefully checked.

Ground tracing.

Second-year Class.

A line of levels about one mile long, the same being carefully checked

A survey, about four square miles in area, by triangulation and traverse (Gale's), the details being filled in by plane-table.

Contouring. Laying out curves. Setting out half widths on side-long ground. Erection of profiles for embankments. Adjustments of instruments. Observations for determining the meridian and latitude.

Third-year Class.

Select a line of railway about five miles long; make a traverse along the same filling in detailed plan by plane-table. Level over this line, and make the needful cross sections.

8.—DRAWING.

Construction of scales. Geometrical construction. Curves of arches, &c. Descriptive Geometry. Orthographic Projection: Of Planes: Of Solids, under given conditions. Sections of solids. Intersection of solids. Development of solids. Shadows. Isometrical Projection. Perspective. Machinery. Topographical drawing.

WORK TO BE EXECUTED BY STUDENTS.

1. Printing. 2. Scales. 3. Geometrical Figures. 4. Arches. 5. Problems in Descriptive Geometry. 6. Projections and Intersections of solids. 7. Intersections of Roofs. 8. Elevations, Sections and Plans of buildings and bridges from copies. 9. Ditto from rough sketches and dimensions. 10. Projections of shadows (simple cases). 11. Free-hand sketches—(*a*) from copies, (*b*) from models. 12. A drawing from actual measurement. 13. Machinery. 14. A simple isometric drawing. 15. A simple perspective drawing. 16. Maps, Sections, &c.

9.—PROJECT.

This will consist of the surveys and levels for a line of canal or railway, about 5 miles long, with cross sections of streams crossed, accompanied by designs for such iron and masonry structures that may be required for the streams or roads that are crossed. The whole to be supplemented by a book of calculations showing how the necessary dimensions have been arrived at.

The drawings that will accompany this project are :—

(1) General plan of country showing adopted line.
(2) Longitudinal section of line.
(3) Design for a masonry bridge.
(4) Design for a plate girder bridge.
(5) Design for an open work bridge, such as a Warren, Lattice, or Bowstring girder.
(6) Such other designs as may be required to complete the Project.

The designs will be got up in sufficient detail to enable the bridges, &c., to be ordered without further information.

10.—MATHEMATICS.

Algebra.

Addition, subtraction, multiplication and division of algebraical expressions (including fractions), highest common factor, lowest common multiple, involution, evolution, theory of indices, surds, simple and quadratic equations involving one or more unknown quantities. Theory of quadratic equations and quadratic expressions. Ratio, proportion, variation Arithmetical, geometrical, and harmonical progressions. Mathematical induction, permutations and combinations. Binomial theorem, exponential theorem.

Trigonometry.

Direction of measurement of straight lines or angles denoted by algebraical sign. Measurement of angles by degrees and circular measure. Definition of the trigonometrical ratios and inverse trigonometrical functions. Investigation of formulæ, including all angles which have the same sine, cosine or tangent. Formulæ expressing the sine, cosine or tangent of the sum or difference of two angles in terms of the trigonometrical ratios of the single angles, with formulæ derived from these. Limiting values of simple trigonometrical functions of an evanescent angle. Sum of a series of sines or cosines of angles in arithmelical progression. Solution of triangles. Properties of triangles. Determination of unknown heights and distances.

Application of Logarithms.

(Each candidate will be supplied with a book of mathematical tables, and required to extract all necessary information from the tables.) Properties and use of logarithms. Numerical solution of triangles. Easy questions in algebra, trigonometry, mensuration, statics, dynamics, or hydrostatics, involving logarithmic calculation.

Mensuration.

The areas of plane figures, and the application of Simpson's rule. Areas of surfaces. Volumes of solids, including the application of the rismoidal formula.

Plane Geometry (including the Geometry of Conics).

Simple problems in the geometry of the straight line, triangle and circle, treated according to modern methods. The more important properties of the parabola ellipse and hyperbola section of a cone. Textbook, Willson's Elementary Geometry and Conic Sections.

Statics.

The composition and resolution forces, acting in one plane on a particle or rigid body. Moments. Bending moments. Conditions of equilibrium of a particle or rigid body, acted on by forces in one plane. Force diagram of a system of forces in equilibrium. Meaning of virtual work and work done by a force. Applications of the above to the solution of problem (the candidate to be allowed the option of adopting the graphic method of solution). Equilibrium of constrained bodies and the simple machines. Determination of centroids. Friction.

Dynamics.

Kinematics.—Velocity and acceleration, uniform and variable. Angular velocity. Numerical value of velocity or acceleration dependent on units of time and space. Relative velocities and accelerations. Composition and resolution of velocities and accelerations. Formulæ connecting time and space described, velocity and acceleration.

Kinetics. - Newton's laws of motion Units of mass, force and work. Relation between force, mass moved, and acceleration produced. Attwood's machine. Motion of projectiles in vacuo. Direct impact of bodies. Co-efficient of restitution. Constrained motion of bodies sliding down smooth curves. Formula (without proof) for the time of a small oscillation of a simple pendulum. Uniform motion in a circle. Conical pendulum. The principles of work and energy. Conservation of energy.

Hydrostatics.

Definition of a fluid, a liquid, a gas. Density and specific gravity of a substance and of a mixture of liquids or gases. Pressure at a point Equality of pressure in all directions in a fluid. Transmission of fluid pressure. The hydrostatic press. Determination of pressure at any point in a homogeneous liquid. Whole pressure on a surface immersed in liquid. Resultant, horizontal and vertical pressure on an immersed surface. Centres of pressure of parallelograms, triangles, circles, or ellipses immersed in any manner in liquid. Conditions of equilibrium of floating bodies. Boyle's and Gay Lussac's laws for gases. The barometer, thermometer, siphon, common pump, air pump, and diving-bell. The atmosphere, pressure at any height in it. Determination of heights by the barometer. Hydrostatic balance. Hydrometers.

Differential Calculus.

Definition of a differential co-efficient. Differential co-efficient of a sum, product, and quotient. Differential co-efficients of simple

functions. Successive differentiation. Leibnitz's theorem. Taylor's theorem. Maclaurin's theorem. Expansions of functions. Maxima and minima values of functions of one variable. Differential equation of the tangent and normal to a curve.

Integral Calculus.

Integration, a limiting form of summation. Integration of simple functions by parts and by substitution. Integration of rational fractions. Integration between definite limits of forms which are generally integrable.

CHEMISTRY.

I. *Pure Chemistry.*—Physical properties of metals used in the arts. Alloys. Behaviour of metals on being heated in contact with air. Investigation into the cause of alteration. Oxygen. Nitrogen. Composition of air. Hydrogen. Detonating mixture; Drummond's lime-light. Physical properties of non-metals. Allotropic modifications. Rapid, slow, and incomplete combustion. Oxides of carbon, sulphur, phosphorus, arsenic, silicon, boron. Metallic oxides. Combination of metals with sulphur. Sulphides of hydrogen and carbon. Chlorine, its preparation and properties. Metallic chlorides. Chlorides of ulphur and phosphorus; hydrochloric acid. Bromine, iodine, fluorine; their compounds with hydrogen. Reduction of oxides by carbon, hydrogen, and sodium. Reduction of sulphides and chlorides. Conversion of oxides, sulphides, and chlorides, into each other; roasting. Electrolysis of water and hydrogen chloride, of the chlorides of ferrosum and ferricum. Displacement of one metal by another in binary compounds. Laws of definite proportions; of multiple proportions, and of atomic weights. Chemical notation Quantivalence. Acids and bases. Salts, normal, acid, basic. Water of crystallization and constitution. Solubility of salts. Natural waters. Formation of salts by the action of acids on oxides and metals. Double decomposition. Principles of alkalimetry and acidimetry. Reduction of salts in solution by metals and by the electric current. Oxidising action of sulphuric, nitric, chromic, and permanganic acids; of chlorine, bromine, and hypochlorites. Ozone. Hydrides of carbon, nitrogen, phosphorus, arsenic, and antinomy. General methods of preparing oxides, hydroxides, chlorides, bromides, iodides, sulphates nitrates, phosphates, carbonates. Determination of molecular formulas and atomic weights; vapour density; law of isomorphism; specific heat; depression of freezing-point The periodic law.

II. *Thermal Chemistry.*—Object. Methods of investigation. Berthelot's calorimeter for solutions. Stohmann's combustion calorimeter. Thermo-chemical notation. Thermal units. Heat of combustion, and of formation. Hess' principle and its applications. Allotropy. Bases and acids. Hydration. Dissociation. Exothermal and endothermal reactions. Application of the principles of Thermo-chemistry to the solution of technical problems.

III. *Chemical Technology.*—Oxygen. Hydrochloric, sulphuric, nitric acids. Phosphorus. Coal gas. Nitre. Sodium, Kastner's process. Common salt. Nitre, Le Blanc's process; ammonia process. Quicklime. Portland cement. Bleaching-powder. Plaster of Paris. Magnesium. Glass and porcelain. Alum. Blanc fixe; zinc white; white and red lead. Silver nitrate.

IV. *Practical Exercises.*—Qualitative analysis of solutions containing K, Na, Mg, Ca, Sr, Ba, Zn, Ni, Co, Fe, Al, Cr, Cd. Cu, Hg, Pb, Bi, Sn. Sb, As, Au, Ag. Analysis of chlorides, sulphates, nitrates, nitrites, carbonates, phosphates, and silicates. Testing for purity of the more common reagents used in analysis. Quantitative analysis of brass, bronze, and aluminium bronze Determination of sulphur and phosphorus in iron ores. Determination of iron in iron ores and in samples of iron by volumetric analysis. Assaying of iron ores in the dry way. Determination of gold by Plattner's process. Testing of drinking-water for ammonia and lead; colorimetric tests. Analysis of lime-stones; elutriation; determination of carbon dioxide.

PHYSICS.

I. Heat.

Expansion; Ramsden, weight-thermometer; Pierre; Regnault's experiments on the absolute expansion of mercury and the expansion of gases. Charles' law. Principles of thermometry. Temperature as measured by the expansion of solids, liquids, and gases. Mercurial themometer; air-thermometer. Thermometers for various purposes. Density of solids, liquids, and gases Absolute temperature. Calorimetry. Specific heats of solids and liquids; method of mixture, Regnault; Bunsen's ice-calorimeter. Specific heat of gases—at constant pressure, Regnault; at constant volume, Röntgen. Dulong and Petit's law; Neumann's law modified by Regnault. Changes of state of aggregation Regelation. Critical temperature; Andrew's experiments. Measurement of heat of fusion and vaporization. Influence of pressure on melting and boiling-point. Methods of liquefying gases. Maximum pressure of vapours; Dalton, Reguault; pressure of saturated steam below and above 100° C. Vapour densities; Dumas', Hoffman's, V. Meyer's methods. Hygrometry; Regnault's hygrometer; psychrometer. Conduction; variable and permanent stages. Simple cases of steady flow across a plate and along a bar; Wiedemann and Franz' experiments. Convection. Joule's determination of the mechanical equivalent of heat.

II. Statical Electricity.

Electrification by friction. Betz' and Ayrton's electroscope. Ice-pail experiment. Induction Ramsden's machine. Electrophorus. Voss' and Whimhurst's influence machines. Electric work and energy. Indicator diagram of electric work. Exploration of electric field. Potential at any point of the field. Lines and tubes of force. Equipotential surfaces; lines of induction. Method of drawing lines of

force and equipotential surface. Measurement of electricity; torsion balance, Hankel's electrometer; attracted disc electrometer; quadrant electrometer. Dimensions. Electrostatic units. Capacity. Condensers; electrification of two concentric spheres; Leyden jar, Lodge's hydraulic model. Specific inductive capacity. Absolute measurement of capacity; statical comparison of capacities; measurement of specific inductive capacity; standard air condenser.

III. Current Electricity.

Chemical and thermal methods of producing currents; Daniell, Grove, Bunsen, Leclanche, Meidinger, Smee; thermopile; thermo-electric battery Pyro-electricity. Classification of bodies as regards transference of electricity. Electrolytic conduction. Electrolysis of fused compounds and of saline solutions. Faraday's laws. The voltameter. Metallic conduction. Ohm's law. Kirchhoff's laws. Units of resistance. Poggendorff's rheochord. Resistance coils. Wheatstone's bridge. Resistance of battery; Mance. Resistance of galvanometer; Thomson. Electromotive force. Standard cells—Raoult, Lodge, Latimer Clark. Determination of electromotive force; statical method; Fechner's and Ohm's methods; Poggendorff's compensation method. Relation of electricity to heat; Joule's law; Lens' experiments. Gaseous conduction. Disruptive discharge. Currents regarded as moving charges; Rowland's and Röntgen's experiments. Flow of electricity and flow of electric energy; outlines of Poynting's theory. Phenomena attendant on the starting, stopping and varying of a current. Oscillating discharges

IV. Magnetism.

Fundamental experiments. Magnetic field. The earth a magnet; magnetic elements; declination theodolite; dip-circle; bifilar magnetometer. Methods of magnetization. Relation of magnetism to electricity. Oersted's expreiment. Tangent and sine-galvanometer; Thompson's reflecting galvanometer; Wiedemann's two-coil galvanometer. Electrodynamic experiments; the solenoid. Electromagnets; types Permeability; its relation to temperature and mechanical stress: critical temperature, its relation to other physical properties. Magnetic hysteresis. Magnetic flux, magneto-motive force, reluctance. The law of traction. Induction of currents; Lenz' law. Direction of induced currents specified by reference to lines of magnetic force. Movement of lines of force with change of magnetization. Self-induction. Ruhmkorff's coil. Electromagnetic units.

V. Radiant Energy.

Laws of a vibrating particle. Harmonic vibrations. Transverse and longitudinal waves. Interference of waves travelling in the same and in opposite directions. Stationary waves. Composition of undulations; elliptical, circular, and rectilinear vibrations. Huyghen's principle Reflection and refraction of thermal, luminous, and electric waves. Velocity of propagation; Foucault's and Fizeau's experiments.

Plane, spherical, and parabolic mirrors. Single and double refraction. *Prisms and lenses. Minimum deviation.* Determination of refractive *indices of solids and liquids. Melloni's experiments on radiant heat.* Hertz' experiments on electric radiations. Outlines of Maxwell's theory of light. Dispersion. Spectroscope and spectra. Conditions of achromatism. Absorption of etherial waves: diathermancy and athermancy; coloured bodies.

VI. Applied Physics.

1. *Heat.*—Ice-making machines. Single and double acting steam-engines. Otto's gas-engine. Petroleum-engines

2. *Light.—Photometry;* Ayrton's dispersion photometer.—*The sextant.*—Different forms of *telescopes.* The simple and the compound *microscope.*—The *camera obscura.* Principles of photography.

3. *Electricity and Magnetism. Storage batteries.—Electro-metallurgy.—Telegraphy* and *telephony.* Batteries in common use. Signals. Single needle instrument; sounder; Morse; relative merits. Siemens' Relay. Line current, local current, double current working; translation. Duplex telegraphy; differential and bridge principle. Overground lines; supports, their preservation; insulators. Faults; in instruments; on line; total, partial, and intermittent. Testing; Wheatstone's bridge; localizing faults; loop test.—Lightning conductor; modern theory; testing.—Bell's telephone. Hugh's microphone. Electric bells.

Dynamo-electric machinery. Silvanus Thompson's definition of dynamo. The ideal simple dynamo. Types of armatures; armature coils and cores. Field magnets. Pole-pieces. Field magnet coils. Commutators, collectors, brushes, brush-holders. Reaction of armature and magnetic field. Lead of brushes; angle of lead. Methods of exciting field magnets. S. Thompson's classification of dynamos. Examples. Dynamos of class I; closed-coil armatures: Gramme for large currents, Victoria dynamo; open-coil armatures: Brush. Dynamos of class II: Siemens' alternate current dynamo. Dynamos of class III: Siemens' unipolar.

Electric lighting. The Brush lamp. The Jablochkoff candle. Edison's and Swan's incandescent lamps. Applications of electric lighting.

Electric measurements and measuring apparatus. The volt and the Ampere. Ayrton's sulphuric acid voltameter. Calibration of galvanometers. Methods of shielding galvanometers. Walmsley and Mather's proportional galvanometer. Ammeters and voltmeters. Permanent magnet meters: Ayrton's; spring meters: Siemens' electrodynamometer; Cunynghame's ammater, Ayrton's magnifying spring ammeter. Gravity control-meters. Electromagnetic control-meters. Relative merits; testing for accuracy; calibration by the calorimetric and the voltameter methods. Cardew's voltmeter. The Ohm; resistance coils; the shunt box; Ayrton's Ohmmeter. The Farad and Micro-farad. The Watt.

METALLURGY.

1. *Iron.*—Blast furnace, Cowper's and Whitwell's stove. Catalan process. South Wales process; refinery; the puddling furnace. Dank's furnace. Steam hammer; rolling mills. Cementation process. Crucible steel. Siemen's open hearth. Siemen's Martin process. Bessemer process. The basic process. Darby's recarburisation process. Méthods of producing sound castings. Tungsten steel. Mitis metal. Mild centered steel.

2. *Copper.*—Welsh process. Mannsfeld process. Cement Copper.

3. *Lead.*—Flintshire process. Scotch-Ore-hearth. Pilz and Rachette furnaces. Lead smelting with basic ferric silicate. English slag-hearth. Patinson's process. Manufacture of sheet lead and leaden pipes.

4. *Zinc*—Belgian and Silesian processes. Manufacture of brass and Muntz' metal. Sheet-Zinc and galvanized iron.

5. *Tin.*—Smelting and refining of tin. Tin plates. Manufacture of bronze.

6. *Mercury.*—Idria and Almaden. Hähner's furnace. Alberti furnace. Landsberg process.

7. *Silver.*—Mexican process. Ziervogel's process. English method of cupellation.

8. *Gold.*—Hydraulic mining. Amalgamation of auriferous quartz. Plattner's process. Gold-parting by sulphuric and nitric acids.

9. *Aluminium.*—Salindres process. The Heroult process.

GEOLOGY.

Object of geology.—Its relation to other sciences. The doctrine of uniformity, its limits.

I. *Astronomical Geology.*—Information obtained from meteorites and by the spectroscope. The nebular theory. Origin of internal heat. Climate in its geological relations; glacial and mild periods; Croll's theory modified by Wallace.

II. *Geognosy.*—The globe and its envelopes. Shape and nature of globe; density; probable internal condition; evidences of pressure and internal heat; isogeothermal surfaces. The age of the earth's crust, Tait's and Wallace's views. Persistence of continental ridges and abysmal depressions. *Petrography.* Macroscopic character of rocks. Microscopic elements; their importance for the study of the history of rocks. Microscopic character of quartz, orthoclase, plagioclase, augite, hornblende, calcite. Essential and accessory constituents. Classification of rocks. Macroscopic characters and essential constituents of the following rocks: limestone, dolomite, quartzite, flint, jasper, hornstone; amphibolite; gneiss, micaceous and chloritic schists. phyllite; granite; quartzporphyry; syenite, trachyte, phonolite, obsidian, pumice; diorite; diabase, dolerite, plagioclase-basalt; sand and gravel, sandstones, conglomerates, breccias, shale, clay; laterites; tuffs peat, lignite. coal, anthracite.

III. *Dynamical Geology.*—Volcanic phenomena; description of volcanoes—kind, shape, distribution, relation to lines of weak resistance

and instability. Theories of vulcanicity. Hot springs. Earthquakes. Secular upheaval and depression. Geological functions of air. Geological functions of water and ice; chemical and mechanical action; denudation and deposition; river valleys; peculiarities of Indian rivers; glacial erosion; formation of lakes. Geological functions of plants and animals; coral islands; Darwin's and Murray's theories.

IV. *Petrogenetic Geology.*—Origin of granite, syenite, diabase, diorite, and basalt. Origin of sedimentary rocks; minerogen, phytogen, and zoogen sedimentary rocks; theories on the origin of coal-beds; origin of laterite. Origin of metamorphic rocks; theories of metamorphism; local and regional metamorphism; origin of rock-cleavage. Ore deposits; origin and classification.

V. *Architectonic Geology.*—Forms of bedding. Surface markings. Concretions. Relative persistence of strata. Overlap. Groups of strata. Joints. Strike and dip; outcrop. Monocline, syncline, anticline. Faults, origin and kinds. Intrusive phase of eruptivity; bosses, sheets, veins and dykes, necks. Interbedded phase of eruptivity; lavas, tuffs. Unconformability.

VI. *Palæontological Geology.*—Object. Conditions for the entombment of organic remains. Preservation of organic remains in mineral masses; fossilization. Uses of fossils in geology.

VII. *Historical Geology.*—Leading principles in stratigraphy. Equivalent strata; absent strata and formations. *General outlines of Indian Geology.* Peninsular Area. The metamorphic series. The transition series. Lower and upper Vindhyans; petrology; Vindhyan basin The Gondwana system; geological position and characters; probable fluviatile origin; relation of Gondwána basins to existing valleys; lower and upper groups; Tálchir; Karhárbari; Damuda; Barákár; Rániganj; Rajmahál; the most important coal-fields. The Deccan trap series; area and petrology. Laterite and lithomarge; distribution, age. Post-tertiary and recent formations; older river gravels and clays; kankar. Indogangetic plain; upland and alluvial soils; red soil, regur, peat. General outlines of the geology of the Himalayan area.

VIII. *Physiographical Geology.*—Terrestial features due to disturbance of crust; monoclinal, symmetrical, unsymmetrical, reversed flexures; alpine type of mountain structure. Features due to volcanic action; the Deccan trap area. Features due to erosion; Indian examples.

IX. *Field Geology.*—Geological surveying; instruments; tracing of boundaries and faults. Sections; how to find direction and amount of dip; clinometers. Levelling; surface profile, datum level, bench-marks, methods of geological levelling. Lithology; practical exercises in the identification of Indian rocks.

MINERALOGY.

Province of mineralogy. Its relation to other sciences.

I. Properties of crystals independent of direction.

Density and specific gravity. Methods of determining specific gravities; hydrostatic balance; pycnometer; Jolly's balance; floatation

methods—Thoulet's, Klein's, Retger's solutions. Separation of rock forming minerals by the floatation method.

II. PHYSICAL CRYSTALLOGRAPHY.

Elasticity. Relation of co-efficient of elasticity to direction. Surfaces of elasticity. Method of determining co-efficients of elasticity in crystals, Koch's apparatus Classification of crystals with reference to elasticity. Physical definition of "crystal"

Cohesion. Cleavage. Fracture. Hardness: Mohs' scale; Pfaff's absolute method. Corrosion figures; Lavizzari's experiment.

Optical properties of minerals. Kind and degree of lustre. Double refraction and polarization. Nicol's prism. Classification of crystals according to their optical properties. Uniaxial and biaxial crystals. Examination of crystals in parallel and convergent polarized light; polarization microscope. Circular polarization Absorption of light; id ochromatic and allochromatic minerals; pleochroism, Haidinger's dichroscope, microscope with one nicol; distinction between augite and hornblende.

Thermal properties. Good and bad conductors; conductivity of single and double refracting crystals; expansion.

Electrical properties. Good and bad conductors; pyro-, actino-, and piezo-electricity, Hankel's researches.

Magnetic properties. Para- and diamagnetic minerals. Separation of rock-constituents by the electro-magnet.

III. GEOMETRICAL CRYSTYLLOGRAPHY.

Relation of physical properties to geometrical form; arrangement of molecules. Crystalline form; faces. Planes of reference; axes, parameters; indices; symbols. Law of rationality of indices, its independence of temperature. Principles of Miller's, Weiss,' Neuman's notation. Fundamental form; its selection. Zones; tautozonal faces; zonal axis; law of conservation of zones. Symmetry; planes and axes of symmetry; principal and common planes Classification of crystals. Fundamental law of physical crystallography. The six crystallographic systems characterized with reference to planes of symmetry. Simple forms and combinations. The holohedral forms of the regular system as modifications of the hexakisoctahedron. Combinations of hexahedron, octahedron, and rhombic dodecahedron. The holodedral forms of the remaining five systems. Closed and open forms; prismatic, tabular and pyramidal habit. Nature of hemihedrism Tetrahedral, pentagonal, and plagihedral hemihedrism in the regular system. Rhombic resp, sphenoidal, pyramidal, and trapezohedral hemihedrism in the hexagonal and tetragonal systems. Sphenoidal hemihedrism in the rhombic system. Hemihedrism impossible in the monosymmetric and asymmetric systems. The nature of Tetartohedrism. Trapezohedral tetartohedrism in the hexagonal system; quartz. Apparently holohedral forms differ from real ones—loss of symmetry by combination with particular hemihedral forms, corrosion figures, circular polarization. Hemimorphism—tourmaline, hemimorphite. Crystallographic mimicry-leucite, sal-ammonia. Groth's method of deducing hemihedral and tetartohedral from holohedral forms. Isomorphism and heteromorphism.

Isomorphous groups of elements. Iso-heteromorphous series of the calcite-arragonite group, of the augite-hornblende group, and of the felspars. Morphotropism and Isogonism. Hemitrophy. Twinning plane, twinning-axis, composition plane. Twins with parallel and non-parallel axes. Contact-twins and penetration twins. Distinctive features of hemitropes. Polysynthetic crystals. Twin striation and combination striation Crystalline aggregates; druses. Pseudomorphism. Pseudomorphs by incrustation, substitution, and alteration; paramorphs. Measurement of angles; contact and reflecting goniometers; relative merits.

IV. Chemical Mineralogy. Calculation of formula. Naumann's classification of minerals. Group tests.

V. Descriptive Mineralogy. A somewhat detailed description of the following minerals—

Elements : diamond, graphite, sulphur, bismuth, copper, silver, gold, platinum. *Sulphides :* pyrite, marcasite, arsenopyrite; leucopyrite; pyrrhotite; galena, chalcosite, sphalerite, argentite, cinnabarite; antimonite; chalcopyrite, bornite.

Sulphosalts : pyrargyrite, proustite, tetrahedrite, stephanite. *Oxides :* cuprite; zinkite; corundum, hematite, menaccanite; spinel, franklinite, magnetite, chromite; quartz, cassiterite, pyrolusite; geothite; limonite. *Oxysalts :* (*a*) carbonates—calcite, dolomite, magnesite, siderite, smithsonite; aragonite, witherite, strontianite, cerussite; azurite; malachite; (*b*) sulphates—anhydrite, barite; gypsum; (*c*) phosphates—apatite; (*d*) silicates—tourmaline; epidote; olivine; calamine; garnet; leucite, nephesite; muscovite, brotite, lithionite; prochlorite, rhipidolite; talc, serpentine; apophyllite stilbite, heulandite; hypersthene pyroxene, amphibol; orthoclase, microcline, albite, indianite, oligoclase-labradorite; kaolinite. *Haloid salts :* sylvite, halite, cerargyrite, fleurite; cryolite.

VI. Practical Exercises Determination of specific gravities. Use of the scale of hardness. Exercises at the polarization microscope. Measurement of angles by the aid of contact and reflecting gonimeters. Blowpipe analysis. Identification of Indian minerals by the aid of Brush's 'manual of determinative mineralogy.'

APPENDIX A.

Course of Study for the Engineer Department

	First year.	Second year.	Third year.	Fourth year, Civil Engineers.	Fourth year, Mechanical Engineers.
Mathematics ...	Algebra, Euclid, Trigonometry, and Mensuration.	Statics, Dynamics, Geometrical Conic Sections.	Analytical Geometry, Differential Calculus, Elements of Integral Calculus.	Integral Calculus, Hydrostatics.	Integral Calculus, Hydrostatics.
Natural Science	Chemistry (or Physics).	Physics (or Chemistry)	Mineralogy ...	Geology and Metallurgy, Practical Chemistry.	Practical Chemistry.
Engineering ...	Field-work ...	Building materials, brick and stone, masonry, earth-work, carpentry, foundations, roads, estimating masonry structures, direct stresses in building materials, surveying.	Construction of walls, floors, and roofs, railroads, irrigation works, arching retaining walls, stresses in roof trusses, estimating iron structures, mechanism, surveying.	Iron bridge construction, transverse stress, deflection stresses in girder bridges, and suspension bridges, torsion, hydraulics, steam-engine, architecture, preparation of civil engineering project.	Tranverse stress, deflection, stresses in girder bridges and suspension bridges, torsion, steam-engine, workshop appliances, machine designs, preparation of mechanical design.
Drawing ...	Printing, geometrical and orthographic projections, scales.	Isometrical, topographical, and free-hand drawing.	Perspective, topographical, free-hand, architectural, and machine-drawing.	Mechanical, topographical and free-hand drawing.	Machine-drawing, free-hand drawing.

ENGINEER DEPARTMENT.

WORKSHOP COURSE.

Workshop hours ... 1 P.M. till 3-30 P.M. daily
Except Saturdays.

FIRST YEAR.

Carpenters' shop.—A complete course in the use of carpenters' and joiners' tools. The students are required to make ordinary joints, stool, boxes, doors, windows, tables, trusses, and the usual framings required in engineering works. Their proficiency in this branch of their practical training is tested at the end of their first year by a carefully supervised examination, and every student must gain half marks before he can be promoted to a higher class.

SECOND YEAR.

Blacksmiths' and Boiler-makers' shop.—The course in this shop comprises the using and handling of the different tools; laying and managing the fires; drawing down, bending, jumping, welding, splitting, punching, chamfering and tempering. The students are required to make small forgings of tools, bolts, nuts, hooks, shackles, parts of roof trusses, and machines. In the boiler-makers' shop they are familiarised with the use of riveting tools and the process of riveting, and learn to punch and shear correctly with the machines for that purpose. Their proficiency is tested at the end of the year by a carefully supervised examination, and every student must gain half marks before he can be promoted to a higher class.

THIRD YEAR.

Vicemen and Fitters' shop.—The course in this shop consists of chipping, filing, and fitting to enable the students to gain experience in the tools used by this class of workmen, after which they make up various tools required in the Fitters' shop, and assist in ordinary fitting work. Their practical skill in this shop is not tested by examination, but in lieu of this they are required to keep note-books in which they sketch to scale the various details of the common machines in the shops, and are expected to be familiar with the working of all machines in the shop.

ENGINEER DEPARTMENT.

ANNUAL EXAMINATION.

MAY 1890.

ARITHMETIC AND ALGEBRA.

1st and 2nd years.

1. Simplify $\dfrac{3\frac{1}{2} + 2\frac{3}{4} - 4\frac{1}{6}}{5 + 1\frac{1}{2} - 1\frac{1}{3}} \div \dfrac{2\frac{1}{2}}{3\frac{4}{5}}$

2. Divide ·6863 by ·2083, and extract the square root of the quotient to three places of decimals.

3. A tradesman bought a quantity of goods and sold $\frac{3}{5}$ of them at a profit of 6 per cent., the price rising he got 10 per cent profit on the remainder, and on the whole he gained £114 : what sum did he lay out?

4. The diameter of a forewheel of a carriage is $1\frac{1}{2}$ feet and that of the hindwheel is 4 feet; how far will the carriage have travelled when the forewheel has made 50 revolutions more than the hind wheel?

5. If the discount on £569-5s. due 7 months hence be £19-5s., what is the rate of interest?

6. Resolve the following into elementary factors :—

$x^2 + 5x + 6$, $8x^3 - y^3$, $a^4 + b^4 + c^4 - \frac{1}{2}(a^2 + b^2 + c^2)^2$

7. Shew that $a^4 + b^4 + c^4 - (a^3 + b^3 + c^3)(a + b + c) + (a^2 + b^2 + c^2)(ab + bc + ac) = abc(a + b + c)$

8. Solve (a) $x + y + z = \dfrac{a^2}{x} = \dfrac{b^2}{y} = \dfrac{c^2}{z}$

(b) $x^2 - 3x + \sqrt{x^2 - 3x + 4} = 2$

(c) Find an equation with real coefficients which shall have for roots $2 - \sqrt{3}$ and $1 + \sqrt{-2}$

9. If $x \propto y^2$ and $x = 4\frac{1}{2}$ when $y = 3$, find x when $y = 5$.

10. Sum (a) $\frac{1}{2} + \frac{1}{6} + \frac{1}{18} + \ldots\ldots$ to infinity.

(b) $2 \cdot 1^2 + 5 \cdot 2^2 + 8 \cdot 3^2 + \ldots\ldots$ to n terms.

11. (*a*) Expand $(2x^3 - 3y^2)^5$

(*b*) Expand $\sqrt{\frac{1-x}{1+x}}$ in ascending powers of x as far as four terms.

(*c*) Apply the binomial theorem to find $9^{\frac{1}{3}}$ to three places of decimals.

GEOMETRY.

1st and 2nd years.

1. Define a plane angle, a segment of a circle, similar rectilineal figures, a scalene triangle, and write out the 8th and 10th axioms.

2. If a straight line falling on two other straight lines make the exterior angle equal to the interior and opposite angle on the same side of the line, the two straight lines shall be parallel.

(*b*) Show how to draw through a given point a straight line to meet two given straight lines which are not parallel, so that the part intercepted may be bisected at the given point.

3. To divide a given straight line into two parts, so that the rectangle contained by the whole and one of the parts may be equal to the square on the other part.

4. If two straight lines neither of which passes through the centre, cut one another within a circle, the rectangles contained by their respective segments shall be equal.

(*b*) If from the centre of a circle a straight line be drawn to any point in a chord, the square on that line, together with the rectangle contained by the segments of the chord, shall be equal to the square on the radius.

5. The opposite angles of any quadrilateral figure inscribed in a circle are together equal to two right angles.

(*b*) If a rectilineal figure of an even number of sides be inscribed in a circle, the first, third, fifth, &c., angles are together equal to the second, fourth, sixth, &c., angles taken together, any angle being assumed as the first angle.

6. In any circle the angle at the centre is double of the angle at the circumference on the same arc.

(*b*) AB is a given chord in a circle whose centre is O, C is a given point in AB; through C draw a chord DE so that the angle AOE may be equal to the angle ADB.

7. To describe a circle about a given triangle.

8. If two triangles have one angle of the one be equal to one angle of the other, and the sides about the equal angles proportional, the triangle shall be equiangular, and shall have their angles equal which are opposite to the homologous sides.

(*b*) From a point O in the circumference of a circle any chord AO is drawn. In AO a point P is taken such that the rectangle OA. OP is constant Show that the locus of P is a straight line and parallel to the tangent at O.

TRIGONOMETRY AND MENSURATION.

1st and 2nd years.

1. Define the unit of circular measure, and prove that arcs of circles subtending the same angle at the centre are proportional to the radii.

Find the angle whose circular measure is $\frac{3}{8}$.

2. The tangent of a certain angle is $\frac{a}{b}$; find the other trigonometrical ratios.

3. Find an expression for all angles which have a given tangent.

Trace the changes in the value of the expression $\frac{\sin\theta - \cos\theta}{\sin\theta + \cos\theta}$ as θ changes from π to 3π.

4. Prove the formula $\sin(A + B) = \sin A \cos B + \cos A \sin B$ in the case when $A + B > 90°$.

Prove that $1 + \cos 2\theta . \cos 2\phi = 2 (\sin^2\theta \sin^2\phi + \cos^2\theta \cos^2\phi)$.

5. Prove that in any triangle $\sin\frac{A}{2} = \sqrt{\frac{(s-b)(s-c)}{bc}}$ and $\sin A = \frac{2}{bc}\sqrt{s(s-a)(s-b)(s-c)}$.

6. In a triangle ABC find B and C, having given $A = 40°$, $b = 131$, $c = 72$.

Log. 5·9	= ·7708520,	L cot 20°	= 10·4389341
Log. 2 03	= ·3074960,	L tan 38° 36′	= 9 9021604
		L tan 38° 37′	= 9 9024195

7. The sides of a rectangle are $2a$, $2b$, and the angles subtended by its diagonals at a point whose distance from its centre is c are α, β: prove that

$$\frac{16a^2 b^2 c^2}{(a^2+b^2-c^2)^2} = a^2 (\tan\alpha - \tan\beta)^2 + b^2 (\tan\alpha + \tan\beta)^2$$

8. Show that the capacity of a tent, considered as a prism of n sides surmounted by a pyramid whose heights are respectively h & h_1, and length of side a is $(3h + h_1)\frac{na^2}{12}\cot\frac{180°}{n}$.

9. A circular building is to be erected on a triangular plot of ground, the sides of which are 40, 30, and 50 yards; find the radius of the circle, so that the unoccupied external area may be $\frac{1}{10}$ th of an acre.

Statics and Dynamics.

2nd year.

1. State and prove the polygon of forces.

If forces proportional to the sides of any polygon act perpendicularly to the sides respectively at the middle points, they will be in equilibrium.

2. State and prove the conditions of equilibrium for any number of forces in a plane.

A uniform beam AB of weight W rests with one end A on a horizontal plane AC, and the other end on a plane CB, whose inclination to the horizon is 60°. If a string $CA = CB$ prevent the beam from sliding, what is the tension of the string?

3. Find the C.G. of a triangle and show that it is the same as that of three equal particles placed at the angular points.

In a triangular pyramid prove that four times the sum of the squares of the distances of the angular points from the C.G. of the pyramid is equal to the sum of the squares of the edges.

4. Find the relation between the power and the weight in the 3rd system of pulleys (neglecting weights of pulleys).

If in this system the weight of the lowest pulley = P, of the second 3P, etc., that of the highest moveable pulley being 3^{n-2} P, find the ratio of P : W.

5. State the laws of limiting friction.

A hemisphere rests between a vertical wall and a horizontal plane, μ and μ^1 being the coefficients of friction of the wall and plane respectively; find the inclination of the base of the hemisphere to the plane when on the point of slipping.

N.B.—The C.G. of a hemisphere is at a distance $\frac{3}{8}$ radius from the centre.

6. Prove the formulæ $v = ft.$, $s = \frac{1}{2}ft.^2$, $v^2 = 2\,fs$, giving the meanings of the symbols involved.

Divide the length of an inclined plane into three parts, so that the time of descent down these successively may be equal.

7. Taking the equation $W = Mg$ how many units are involved, and what is the relation between them?

If the unit of weight be the weight of 5lbs., and the unit of acceleration, referred to a foot and a second, be 3, find the unit of mass.

8. Show that the path of a projectile in vacuo is a parabola.

Prove that if a shot be projected on a vertical target, it will, as seen from the point of projection, appear to descend with constant velocity

9. State the experimental law on which the determination of the motion of two elastic bodies depends; and show for the case of direct impact that the kinetic energy after impact is never greater than that before.

ENGINEERING.

2nd year class.

1. What are the three classes into which building stones are divided? Mention as many specimens as you can of each class.

2. Define the following terms as applied to limes:—Fat, poor, slightly hydraulic, hydraulic, eminently hydraulic.

3. Discuss fully the selection of a good building stone under the heads strength, durability, and facility of working. Name a stone remarkable for each quality.

4. What is the part performed by mortar in masonry, and hence show what its quality should be.

5. Describe the growth and construction of a timber tree, and state the object and usual method of seasoning wood by natural drying.

6. What are the metals chiefly used in engineering work? Give instances of two or three ordinary applications of each.

7. How are metals found in nature, and how are they purified? Take iron as an example, and detail the processes to produce pig iron.

8. State what you know of the mode adopted in blasting the Mont Cenis tunnel. Illustrate the method by sketches.

9. How are tiles made, dried, and burnt? Why is the manufacture of good tiles more costly than that of bricks?

10. Would you have the materials mixed in the same proportions for mortar intended for plaster and that to be used in masonry? Give your reasons.

11. How would you prepare an artificial cement from chalk and clay?

12. Describe two rough methods of ascertaining the value of lime stone for mortar.

[You are not to attempt more than 8 of the above questions.]

ESTIMATING.

2nd year.

Make an estimate of the bridge from the following rates:—

Arch masonry @ Rs. 28 per 100 c.ft.
Plain masonry @ „ 24 „ „ „
Plastering @ „ 3 „ „ s.ft.

N.B.—All exposed surfaces to be plastered.

SURVEYING.

1st year to do the first 9 questions.
2nd year ditto: 5 ditto & 10, 11, 12 & 13.

1. Describe briefly the method of chain surveying. What check is used?

2. What is Gunter's chain, and when is it used?

A tract of country is computed to contain 36,000 square yards, but it is found that the 100 ft. chain used was really 2 inches too long; determine the correct area.

3. Distinguish between an angle and bearing in surveying.

In what way is a prismatic compass survey carried out?

4. To within what distance must your measurements be correct if your scale be 500 ft. = 1 in., so that the accuracy of your plan may not suffer?

If you had only a prismatic compass with you, how could you determine the position of any object to plot on your plan?

5. What is the meaning of parallax, and how do you get rid of it?

6. How could you determine the distance to an inaccessible object (say on the other side of a river) when you have only a chain or tape with you?

7. How could you also find out the height of this object under the same conditions?

8. What levels are you acquainted with?

If the permanent adjustment of your level was out, what precautions would you have to take in order to get accurate work?

9. Briefly describe the 3 permanent adjustments of a Y-level?

10. Explain the principle of the moveable vernier. The plate of a theodolite reads to 10 minutes and the vernier is required to read to 15 seconds. Explain, with sketch, how it should be constructed.

11. Describe the principle of Gale's Traverse System and the conditions which must be fulfilled by a complete circuit. What are the advantages claimed for it, and to what sort of country is it best adapted, and why?

12. How would you set out a curve by chords and offsets without an angular instrument?

13. If there be some difference on closing, how would you correct this?

What length of chord would you use for a radius of 15 chains?

DRAWING.

1st year.

1. (*a*) Draw geometrically a square equal in area to a rectangle whose adjacent sides are 3″ and 1″.

(*b*) In a circle of 2½ inches diameter construct a regular pentagon.

2. Construct a semi-ellipse, major diameter 3½ inch and semi-minor diameter 1 inch.

3. Construct the following scales:—

(*a*) A scale of yards R. F. $= \frac{1}{360}$.

(*b*) A diagonal scale of 1 inch to the mile shewing furlongs

4. Draw the traces of a triangular plane of which the projections are *abc* and a′b′c′.

5. Draw sectional elevation on the line AB of a flight of steps of which the plan and elevation are given.

6. Draw projections of a hollow cylinder 3 inches long, outer diameter 1¾ inches, inner diameter 1¼ inches, placed on the horizontal plane with its axis making angle of 45° with the vertical plane.

DRAWING.

2nd year.

1. Print "Seebpur" in plain block type ½ inch high, and the following sentence in italics:—"You will never learn to print italics if you labor over each letter."

2. Find by construction only the side of a square, the area of which shall be 800 square feet. Scale $\frac{1}{120}$.

Describe an ellipse with diameters of 3·7 and 2·3 inches.

3 Draw a vernier (to double size) to read 27·686 inches The vernier to be capable of reading $\frac{1}{500}$ of an inch.

Also a diagonal scale of 10 feet to the inch shewing inches diagonally.

4. A hexagonal chimney passes through a roof inclined at an angle of 35°. Draw the true shape of hole in roof. Side of hexagon 1 inch and one side inclined at an angle of 10° to edge of roof.

5. A circular dome is intersected by a semi-circular arched passage. Find the projections of the intersection, under the following conditions :—Radius of dome, 50 feet ; span of arch of passage, 30 feet ; height of wall of passage from floor to springing 15 feet. The floor of the dome and passage are on the same level, the plan of the axis of passage passes through that of the axis of the dome.

6. Shew the intersection of above laid out flat on the paper. Scale optional.

CHEMISTRY.

[20 marks are reserved for the note-book.]

1. Give a concise but complete account of the method which we have adopted in order to find out the cause of the change which certain metals undergo when heated in contact with air. (No sketches.)

2. State the three fundamental laws of statical chemistry.

3. Write down in columns the formulas of the chlorides, oxides, hydroxides, sulphates, carbonates, and nitrates of the following metals :—

Potassium, calcium, ferricum, silver, lead, aluminium, zinc, sodium.

4. Calculate the percentage composition of nitrogen·pentoxide, sulphur dichloride, cupric sulphate (anhydrous), silver nitrate.

5. Define—salt, base, acid, normal, acid, basic salt, anhydro-salt.

6. What is meant by a dibasic acid ? Give examples of a normal salt having acid reaction, of a basic salt having neutral reaction, of a normal salt having alkaline reaction.

7. Arrange twenty of the more common metals according to their quantivalence. Give four examples of variable quantivalence among metals and non-metals.

8. You have to separate the following metals in solution from each other :—silver, copper, nickel, iron, zinc, calcium. State how you would proceed.

9. By what methods could you reduce cupric sulphate to the metallic state ?

PHYSICS.

1. Describe Regnault's method of determining the maximum pressure of aqueous vapour above and below 100

2. Describe Daniell's hygrometer. How would you use it? Give full explanations.

3. Develop the formula for the coefficient of conductivity. In what different ways may heat be transmitted from one place to another?

4. The specific heat of lead is 0·031, its latent heat of fusion is 5·37. What is the mechanical equivalent of the heat necessary to raise five kilograms of lead from the temperature of 270°C. to its melting point 335°C. and then to melt it?

5. State the laws of reflexion and refraction of light.

6. Define—index of refraction, critical angle, dispersion, prism, refracting angle.

7. Draw a longitudinal section of the human eye, and enumerate its different parts.

8. Describe three experiments, proving that within a closed conductor there is no electrical force due to a charge residing on the conductor?

9. Explain how a plate electrical machine can be used as a source of electricity.

10. Describe Bunsen's element and explain its action.

ENGINEER DEPARTMENT.

FIRST EXAMINATION IN ENGINEERING, 1890.

Arithmetic and Algebra.

Examiner—Mr. C. Little, M.A.

1. Find the value of $(\cdot 9887)^{10}$ correct to five places of decimals.

2. Add together $\frac{5}{11}$ of $1\frac{5}{17}$, $\frac{1}{10}$ of $\frac{37}{34}$, $5\frac{1}{2}$ of $\frac{3}{55}$, and $19\frac{6}{11} \div 1\frac{1}{4}$.

Simplify $\dfrac{5\cdot 1183}{\cdot 0141}$ of $22\cdot\dot{2}$ of $\cdot 0\dot{9}$ of $\cdot 2\dot{3}\dot{4}$.

3 If 5 men can dig a trench 50 ft. long, 10 ft. broad and 2 yards deep in a given time, how many men will be required to dig another trench twice as long, three times as broad and 3 yards deep in the same time?

4. If I buy two sorts of tea—the one at £20 per cwt., the other at £15 per cwt., how must I mix them, so that by selling the mixture at 3*s*. 8*d*. a lb., a profit of 10 per cent. may be made?

5. Find the greatest common measure of
$2x^4 + 9x^3 + 14x + 3$ and $3x^4 + 14x^3 + 9x + 2$.

6. Simplify—

(1) $\dfrac{1}{x^2 - 5x + 6} - \dfrac{2}{x^2 - 4x + 3} + \dfrac{1}{x^2 - 3x + 2}$.

(2) $\dfrac{1}{a - b + \dfrac{1}{a - \dfrac{1}{b}}}$.

7. Solve the equations—

(1) $\dfrac{6x - a}{4x + b} - \dfrac{3x - b}{2x - a} = 0$.

(2) $\dfrac{1}{x + a} + \dfrac{1}{x + b} = \dfrac{1}{c + a} + \dfrac{1}{c + b}$.

(3) $x^2 - y^2 = 8x - 16$.
$3xy = 6x + 7y$.

8. If $a : b :: c : d$
prove that (1) $a + b : a - b :: c + d : c - d$.
(2) $a : a + c :: a + b : a + b + c + d$.

9. Find the sum of n terms of a Geometrical Progression.

Prove the rule for expressing a recurring decimal as a fraction, and show its application to $\cdot 2\dot{3}\dot{4}$.

10. Prove the Binomial Theorem for a positive integral exponent.

Write down all the terms of $\left(5 - \frac{x}{6}\right)^6$, and apply the formula to find its greatest term when $x = 26$.

11. Prove that $\log_e \frac{a}{b} = \log_e a - \log_e b$.

Having given that

$$\log 5{\cdot}7214 = {\cdot}7575023$$
$$\text{and } \log 5{\cdot}7215 = {\cdot}7575099$$

write down the corresponding table of differences and find the logarithm of 572147.

Plane Geometry and Geometrical Conic Sections.

Examiner—Mr. C. Little, M.A.

1. Draw a straight line perpendicular to a given straight line of unlimited length from a given point without it.

By drawing a perpendicular from the vertex of an isosceles triangle to the base, prove that the angles at the base are equal, stating the theorems required in the proof.

2. Prove that parallelograms on the same base and between the same parallels are equal to one another.

ABCD is a quadrilateral having BC parallel to AD; E is the middle point of DC. Show that the triangle AEB is half of the quadrilateral.

3. If a straight line be divided into two equal and also into two unequal parts, prove that the squares on the two unequal parts are together double of the square on half the line and the square on the line between the points of section.

4 Prove that in a circle the angle in a semicircle is a right angle; the angle in a segment greater than a semicircle less than a right angle; and the angle in a segment less than a semicircle greater than a right angle.

If AC be the diameter of a circle, and if any other circle be described with centre C, chords of the latter circle, which produced if necessary pass through A, are all bisected by the former circle.

5. Similar triangles are to one another in the duplicate ratio of their homologous sides. Prove this.

Find a point D in the side AC of a triangle ABC, so that DE being drawn parallel to AB and terminating in CB, the triangle CDE may be to the trapezoid DB in the ratio 4 : 5.

6. If the tangent at a point P of a parabola intersect the directrix in Z, prove that SZ will be at right angles to SP.

PG is the normal at P cutting the axis in G, prove that the perpendicular from the focus on the normal bisects PG.

7. Prove that in an ellipse, if CP be conjugate to CD, CD will be conjugate to CP.

If CP and CD be conjugate, and SP be joined cutting CD in V, prove that PV = CA.

8. If from a point O a pair of tangents OP, OP′ be drawn to a hyperbola, prove that the angles which OP and OP′ subtend at either focus will be supplementary if the points of contact be on opposite branches of the hyperbola.

9. Tangents at the extremities of a pair of conjugate diameters of an ellipse meet in T: prove that ST, S′T meet the conjugate diameters in four points which lie on a circle.

Trigonometry and Mensuration.

Examiner—Mr. C. Little, M.A.

1. Assuming that $\pi = 3{\cdot}14159$, express 4° 12′ 59″ in circular measure correct to the fourth decimal place: and find to seconds the angle whose circular measure is ·8

2. Define the cosine, cotangent and versine of an angle.

Prove that (1) $\cot A = \dfrac{\cos A}{\sin A}$,

(2) $\tan^2 A = \sec^2 A - 1$.

If $1 + \sin^2\theta = 3 \sin\theta \cos\theta$, find $\tan\theta$.

3. Find the trigonometrical ratios of $\pi + A$ in terms of those of A.

Find the values of the sine, tangent and secant of 675° and 585°.

4. Prove that

(1) $\sin(A - B) = \sin A \cos B - \cos A \sin B$.

(2) $\cot 2A = \dfrac{\cot^2 A - 1}{2 \cot A}$.

(3) $\sin 3A = 4 \sin A \sin(60° + A) \sin(60° - A)$.

5. Prove that in a triangle

(1) $\tan \dfrac{A}{2} = \sqrt{\dfrac{(s-b)(s-c)}{s(s-a)}}$.

(2) $c^2 = 2(a^2 + b^2) - (a + b)^2 \cos^2 \dfrac{C}{2} - (a-b)^2 \sin^2 \dfrac{C}{2}$.

6. If $a = 250$, $b = 240$ and A = 72° 4′ 48″, find the angles B and C, stating, with reasons, if they can have more than one value each.

Given log 2·5 = ·3979400. L sin 72° 4′ = 9·9783702
log 2·4 = ·3802112. L sin 72° 5′ = 9 9784111
L sin 65° 59′ = 9·9606740.

7. Find the greatest angle of the triangle, whose sides are 50, 60 and 70 respectively, having given log 6 = ·7781513, L cos 39° 14′ = 9·8890644, diff. for 1′ = 1032.

8. Planks one inch thick are cut out of a cylindrical block of wood one foot in radius by sawing it through parallel to its axis, and

then cutting off the curved edges of the sections. Find correct to a tenth of an inch the width of the flooring formed by laying the planks side by side.

9. The base of a pyramid covers a square of $13\frac{2}{3}\frac{1}{4}\frac{7}{4}\frac{7}{5}$ acres, and its height is 480 feet, find a side of the square and the volume of the pyramid.

10. How many coins each $1\frac{1}{3}$ in. in diameter can be arranged on a circular table 20 in. in diameter, in the form of a regular hexagon?

Statics and Dynamics.

Examiner—Mr. C. Little, M.A.

1. Two forces P and Q are given inclined at an angle a, prove that the square of the resultant $= P^2 + Q^2 + 2PQ \cos a$.

Enunciate the theorem called the 'Polygon of Forces.'

Determine the resultant of four forces of 5, 6, 9, 10 lbs. acting on a particle and represented in direction by OA, OB, BC, and BD respectively, where O is the point of intersection of the diagonals of a square ABCD.

2. Find the resultant of two unlike parallel forces.

A uniform bar AB 10 ft. long and weighing 50 lbs. rests on the ground. If a weight of 100 lbs be laid on it at a point distant 3 ft. from B, find what vertical force applied at the end A will just begin to lift that end.

3. Prove that two couples acting in a plane and tending to turn in the same direction produce the same effect if their moments are equal.

4. A circular lamina of mass m rests on two smooth pegs in the same vertical plane. Find the pressures on the pegs, their positions being at angular distances θ, ϕ respectively from the lowest point of the lamina.

5. Find the centre of gravity of a plane triangle.

From a square lamina a portion is cut away of the form of an isosceles triangle having its base coincident with a side of the square: find the centre of gravity of the remainder.

6. Find the relation between the power and weight in a lever, when the weight is on the point of motion.

Show that the power necessary to move a cylinder of radius r and weight W up a plane inclined at an angle a to the horizon by a crowbar of length l inclined at an angle β to the horizon is

$$\frac{Wr}{l} \frac{\sin a}{1 + \cos (a + \beta)}.$$

7. State how velocity and acceleration are measured.

Prove the formula $v^2 = u^2 + 2fs$.

A body after falling for two secs. is overtaken by another let fall 336 ft. above it: how long has the latter been falling?

8. Find the time of flight of a projectile and its range on an inclined plane.

If α be the angle of projection of a projectile and θ the angle which its direction makes with the horizon when it strikes a given mark, whose angular elevation above the horizon is β; show that

$$\tan \alpha + \tan \theta = 2 \tan \beta.$$

9. A body moves in a circle with uniform velocity, find the acceleration to the centre.

If the radius of the earth supposed to be at rest be taken as 4,000 miles, find the velocity with which a body will move uniformly along the equator, and the time necessary for a complete revolution.

10. Two masses m, m' moving in the same straight line with velocities u and v impinge: fin dthe velocities after impact, the co-efficient of elasticity being 1.

A mass of 10 lbs. moving northwards with velocity 20 impinges on a mass of 15 lbs moving eastward with velocity 10. At the instant of impact the two masses cohere. Find the velocity of the combined mass, and indicate its direction by a figure.

Analytical Geometry.

Examiner—Mr. C. Little, M.A.

1. Show that the general equation of a straight line may be put in the form $\frac{x}{a} + \frac{y}{b} = 1$.

Find the equation of the straight line which passes through the point of intersection of the lines $3x + 2y - 5 = 0$, and $5y - x + 7 = 0$, and through the point (4, 5).

2. Find the length of the perpendicular from a given point on a given straight line.

Find the length of the perpendicular from the origin upon the straight line which joins the points $(a \cos \alpha, a \sin \alpha)$, $(a \cos \beta, a \sin \beta)$, and show that the perpendicular bisects the distance between the points.

3. If the axes of co-ordinates be turned through an angle θ, and (x, y), $(x' \; y')$ be the co-ordinates of a point referred to these axes in their two positions, show that

$$x + y \cos \omega = x' \cos \theta + y' \cos (\theta + \omega)$$
$$y \sin \omega = x' \sin \theta + y' \sin (\theta + \omega)$$

where ω is the angle between the axis.

Transform $5x^2 + 4xy + 5y^2 - 60x - 66y + 286 = 0$ to new rectangular axes through the point (4, 5) the new axis of x making an angle of 30° with the old.

4. Find the equation of the parabola referred to the axis and directrix as axes of co-ordinates.

PT being a tangent to a parabola $y^2 = 4ax$ whose focus is S, show that the locus of the centre of the circle circumscribing the triangle SPT is $y^2 = (x - a)^2 \left(1 - \frac{2x}{a}\right)$, T being the point where the tangent cuts the axis of the parabola.

5. Find the equation of the tangent at any point of the ellipse $\frac{x^2}{a^2} + \frac{y^2}{b^2} - 1 = 0$.

In the ellipse whose equation is $x^2 + 4y^2 = a^2$, find the length of the latus rectum and one of the equi-conjugate diameters; also find the equations of the tangents at one extremity of the latus rectum and one extremity of an equi-conjugate diameter.

6. If l_1, l_2 be the lengths intercepted by the major axis on two normals which are at right angles, show that

$$\frac{1}{l_1^2} + \frac{1}{l_2^2} = \frac{a^2 + b^2}{b^4}.$$

7. Prove, for the hyperbola, that the product of the perpendiculars from the foci on any tangent is constant.

Find the co-ordinates of the point of intersection of tangents at the points $(a \sec \alpha, b \tan \alpha)$, $(a \sec \beta, b \tan \beta)$.

8. Prove that the line $y = \sqrt{3x} + 2$ touches both the parabola $y^2 = 8\sqrt{3x}$ and the hyperbola $\frac{x^2}{a^2} - \frac{y^2}{3a^2 - 4} = 1$.

GEODESY.

Examiner—MR. G. A. G. SHAWE.

1. Construct a diagonal scale of 7 miles to one inch, to show miles and furlongs. What is the representative fraction of this scale?

2. If after chaining a distance of 3,147 feet with a chain of 100 feet, you find by measurement of the chain that it is two inches too long, what is the true length of the line measured?

3. Describe briefly, but clearly, the principle on which moveable vernier scales are made.

In an upright vernier, the primary scale is three inches long, and divided into tenths of an inch. Draw this, as well as the moveable scale in its proper position when the reading is 1·67 inches.

4. How would you find the distance to an inaccessible point, on the other side of a river, without the use of any instrument to measure angles?

5. How do you ascertain whether the horizontal wire of a Dumpy level is in adjustment? If found to be out of adjustment, how do you correct the error?

6 Suppose you have to run a traverse of a six-sided piece of flat ground ABCDEF. The theodolite having been set up and levelled at the first station A, describe briefly each *subsequent* step in the manipulation of the instrument required for the observations at A. What observations would you make at the next station, B? Having completed the traverse, what calculations would you make to satisfy yourself that your observations and measurements were correct?

7. You are given a map of a flat area like the Calcutta maidan, and directed to contour it so as to show rises and depressions exceeding 1 foot. Show how this is done.

8. Two straight lines have been flagged out on the ground, meeting at an angle of 125°, and you are directed to connect them with a curve of radius = 1432 feet. How do you determine

(1) the position of the points where the curve begins and ends?

(2) the angle of deflection for chords of 100 feet (in stating this angle, seconds may be neglected)?

(3) the length of the curve?

MATERIALS OF CONSTRUCTION.

Examiner—MR. W. CONNAN.

(*Only 8 questions to be answered.*)

1. Note building stones obtainable in Behar, Orissa and Chota Nagpore.

2. Describe the quarrying of stone by blasting. What determines the strength of gunpowder charges?

3. In ashlar masonry it is specified "stones are to be laid on their natural bed." To what classes of stone does this apply? Give reason for specification.

4. Give a practical test for the selection of alluvial clay for brick-making. Note ordinary processes in Bengal for tempering clay and moulding bricks.

5. Sketch a section of a 3-lakh open coal brick clamp, giving dimensions, noting coal and brick courses and amount of coal in each course for Calcutta.

6. Define 'fat lime,' 'hydraulic lime,' 'hydraulic cement,' and give ordinary proportions of materials for a mortar of each.

7. Sketch neatly a section of an ordinary country kiln for burning "ghooting," noting proportions of fuel and material used in it (wood burnt or coal burnt) and outturn that may be expected.

8. Compare the resistance to crushing of mortars under-noted: —

1 Portland Cement	to	3 sand.
1. Kutnee lime	to	3 soorkhee.
1 Ghooting lime	to	2 soorkhee.

9. Give composition of Portland Cement and the tests imposed in its selection.

10. What determines the proportion of materials for Concrete? Give proportions for foundation work Calcutta, and specify procedure to be adopted in laying.

11. Describe the manufacture of a W.I. rail from the "bloom" and note tests enforced for a 75 lbs. rail.

12. Give the composition of "gun-metal," "brass" and "bronze."

Chemistry.

Examiner—Mr. A. Pedler, F.C.S.

1. Define clearly what is meant by the following terms, illustrating your meaning as far as possible by examples:—Acid, base, salt, compound radical, acid radical, atomic weight, and atomicity.

2. 50 grams of Sodium Carbonate are acted on by a solution containing 40 grams of Hydrochloric acid. What will be the weights of any new substances formed, and if any gas will be produced, what will be its volume at 7°C. and 684 m.m. pressure?

3. State clearly how you would analyse atmospheric air and how you would prove the presence of each constituent. What is it composition? Do we express it by a chemical formula? Give your reasons for the statement made. What action has pure water when shaken up with a small quantity of air?

4. The following substances are heated to redness in a current of air. State if any changes take place, and if so, give the chemical equations representing them:—(*a*) Iodine, (*b*) metallic iron, (*c*) silicon dioxide, (*d*) calcium carbonate, (*e*) clay, (*f*) metallic lead, (*g*) sulphur and (*h*) slaked lime.

5. What are the usual constituents of river, tank, and well water? What are the tests you would employ to detect these ingredients? What is meant by the "hardness" of water, and to what substances is it due?

6. Take up six of the metals commonly used, and discuss their physical and chemical properties. State how the uses to which these metals are put depend on such properties.

7. Samples of minerals were given which might be either Dolomite, Limestone, Witherite, Strontianite, Heavy Spar or Gypsum; state what chemical tests you would employ to distinguish them.

8. How is Gold found in nature, and how is it extracted from its ores? How would you detect if a mineral contained gold or not?

9. Explain very briefly how iron is reduced from its ores in the blast furnace, also how pure iron or wrought iron is made from pig iron, and how steel can be made from either pig or wrought iron.

Light and Heat.

Examiner—Mr. A. Pedler, F.C.S.

1. Describe briefly the various methods which are employed to determine the velocity of light, if possible illustrating your explanations by examples.

2. Describe the construction of Bunsen's Photometer, and show clearly the principles on which it depends. How many candles are required to produce at a distance of 50 yards the same illuminating effect as one candle at a distance of nine yards?

3. Explain briefly what is meant by the terms reflection of light, dispersion of light, refraction of light, interference of light and polarization of light. State generally on what theory these properties of light are explained.

4. The various kinds of light emitted by (*a*) the lime light, (*b*) the flame of burning sodium, (*c*) the electric light, (*d*) a Geissler's tube containing hydrogen, through which an electric current is passing, (*e*) the sun, and (*f*) the light from an electric lamp which has passed through a heated tube containing sodium vapour, are examined by a *spectroscope. Explain clearly what will be seen in each case, and show* how the phenomena can be accounted for.

5. Describe clearly how you would prepare (*a*) a maximum thermometer and (*b*) a minimum thermometer. Indicate clearly the sources of errors generally in thermometers. How would you read each of these thermometers? Convert 56°F,—10°F, and 112°F to degrees Centigrade and Reaumur and — 5°R, — 10°C, and 25°C to degrees Fahrenheit.

6. Explain clearly what is meant by the terms specific heat, latent heat of fusion, and latent heat of vaporization, and how can the latent heat of water and of steam be determined?

20lbs of water at 20°C are added to 50lbs. of ice at 0°C, 5lbs. of steam at 100°C are then added. Supposing that no heat is gained or lost by external circumstances, state what will be the final result of such mixture.

7. One pound of charcoal on burning to produce carbon dioxide, produces heat sufficient to raise 8080 pounds of water through 1°C. Calculate what will be the theoretical temperature of (*a*) charcoal burning in oxygen, and (*b*) charcoal burning in air, if the temperature to commence with is 0°, (sp. heat $CO_2 = 0{\cdot}2164$; sp. heat $N = 0{\cdot}2438$).

8. Describe briefly the more important parts of a Watt's Steam Engine, stating their relations to each other, and the part they play in the working of the engine. How can you calculate the proportion of heat theoretically capable of being utilised in a heat engine?

9. Describe Joule's and Meyer's methods of determining the mechanical equivalent of heat

A leaden bullet weighing 100 grams and moving with the velocity of 100 metres per second strikes against an iron target. How much heat is produced, and on the supposition that the whole of the heat so generated remains in the leaden bullet, through how many degrees centigrade will the temperature of the bullet be raised? (specific heat of lead = 0·0314).

Electricity, Magnetism and Telegraphy.

Examiner—Mr. A. Pedler, F.C.S.

1. Describe the method of construction and of working a cylinder electrical machine. Explain the precise source of the electricity generated. How would you charge a series of Leyden Jars by "Cascade" with such a machine.

2. You are given the materials necessary for the preparation of an electroscope. State clearly how you would prepare it, and how you would use it in testing electrical charges and in proving their nature.

3 Describe the construction of a cell of either Bunsen's or Daniell's battery, and point out what change takes place when the cell is in action. An electric current is passed successively through the following solutions:—Zinc sulphate, Hydrochloric acid, Sodium sulphate, Cupric chloride, Ferric chloride, and water acidulated with Sulphuric acid. One gram of hydrogen is evolved in the last case. What reactions will take place in the other solutions, and what weights of new products will be obtained?

4. What is meant by thermo-electricity, and how can its phenomena be shown? How is a thermopile constructed, and what takes place when the faces are heated alternately?

5. Explain very clearly the use of lightning-conductors, and state briefly what are the main points to be attended to in protecting a building by conductors. Show how with a galvanometer and a small battery you could test whether a lightning-conductor is in order or not.

6. Explain the usual methods of making permanent magnets. If you had made two permanent magnets, how would you be able to compare their relative strengths?

7. What is meant by the terms magnetic declination and dip? How are they measured?

State what you know with reference to the Earth's magnetism.

8. Describe and explain briefly any magneto-electric machine you are acquainted with

9. Describe Wheatstone and Cooke's single needle Telegraph, pointing out the particular use of each part, and the method of using single needle telegraphs.

Drawing.

Examiner—Mr. W. Banks Gwyther, A.R.I.B.A., A.M.I.C.E.

Drawings to be made in pencil only and lines used in construction to be left. Neatness and clearness will be taken into consideration in allotting marks.

1. Draw a scale of 3 inches to a mile, to read multiples of 10 yards.

2. In the middle of a square of 2 inches side construct geometrically another square which shall contain one-third of the area of the original square.

3. A square prism having a base of 1 inch side, and a height of 2 inches is made to balance on one of its points, and then swung round till the plane of its axis makes an angle of 45° with the ground line: draw its elevation in this position.

4. Show on the accompanying elevation (Fig. i) the shadows occurring on it by light striking at the conventional angle.

5. Two egg-shaped sewers of the section shown in Fig. ii meet at an angle of 120° : draw their intersection.

6. Draw the brick pillar detailed in Fig. iii. in isometric projection, and show alongside a perspective view of it, when the picture plane AB and the station point S are in the positions given in Fig. iii.

7. Draw plan, elevation and section on CD of a gateway and lodge from the following specification :—

(*a*) Arrangement to be as in Fig. iv.
(*b*) Walls to be of 15″ brickwork.
(*c*) Roof to be flat terraced, resting on T-irons, and (where necessary) joists. Plinth to be raised 2 feet, and room to be 12 feet from floor to under side of T-irons in roof.
(*d*) Covered verandah to be provided in front of lodge.
(*e*) Iron railing 5 feet high to rest on a dwarf wall 2 feet high.
(*f*) Scale, 8 feet to an inch.
(*g*) No minute detail need be shown.

8. Draw to about half size in light and shade and without measuring or ruling, the block of terra cotta put before you.

ENGINEER DEPARTMENT.

L. E. AND B. E. EXAMINATIONS, 1890.

DIFFERENTIAL AND INTEGRAL CALCULUS.

Examiner—MR. C. LITTLE, M. A.

1. Define a differential coefficient, and hence deduce the differential co-efficients of a^x, $\tan x$ and x^4.

Differentiate $\sin(a + bx^n)$, $\tan^{-1}\dfrac{\sqrt{x} - x^{\frac{3}{2}}}{1 + x^2}$,

$\sqrt{\dfrac{1 - x}{1 + x + x^2}}$ and $\log \dfrac{x^2 + x + 1}{x^2 - x + 1}$.

2. Find the nth differential co-efficient of $\sin(ax + b)$ in the form $a^n \sin\left(ax + b + \dfrac{n\pi}{2}\right)$.

If $y = ax \sin x$, prove that

$$x^2 \frac{d^2y}{dx^2} - 2x \frac{dy}{dx} + (x^2 + 2)\, y = 0$$

and hence find the relation connecting $\dfrac{d^n y}{dx^n}$ and consecutive differential co-efficients.

3. Prove Maclaurin's theorem.

Show that $\tan^{-1} x = x - \dfrac{x^3}{3} + \dfrac{x^5}{5} - \dfrac{x^7}{7} + \&c.$

4. Show how to find the value of $\dfrac{f(x)}{\phi(x)}$ when each function becomes zero on the substitution of a for x.

Find the value of $\dfrac{1 - \tan x}{1 - \sqrt{2} \sin x}$ when $x = \dfrac{\pi}{4}$.

5. Define a maximum and a minimum value of a function. Illustrate geometrically the statement that in general $\phi(x + h) - \phi(x)$ and $\phi(x - h) - \phi(x)$ are of opposite sign.

6. Show how to integrate the following expressions :—

$$\int \frac{dx}{\sqrt{a^2 + x^2}}, \int \frac{dx}{a^2 + x^2},$$

$$\int \operatorname{cosec} x \cot x \, dx, \int \frac{ax + b}{\sqrt{ax^2 + 2bx + c}} \, dx, \text{ and}$$

$$\int \frac{dx}{x^4 + 3x^2 + 2}.$$

7. Prove that $\int_0^\infty \frac{dx}{1 - x^4} = \frac{\pi}{4}$,

and that $\int_0^{\frac{\pi}{2}} \sin^7 x \cos^4 x \, dx = \frac{4^2}{3.5.7.11}$.

8. Find by the method of integration the area of a quadrant of an ellipse ; also find the area of a loop of the curve $r = a \cos n\theta$.

9. Find the volume of the surface traced out by the revolution of an ellipse about a directrix.

Hydrostatics.

Examiner—Mr. C. Little, M.A.

1. Prove that at a point in a fluid, pressure is the same in all directions.

If pressure be uniform over the whole of an equilateral triangle exposed to liquid pressure, find the pressure at any point of it, if the whole force on the triangle be P, and the length of a side a.

2. Show how to find the specific gravity of a mixture when the weights and specific gravities of the components are given.

The specific gravities of pure gold and copper being 19·3 and 8·9, find the specific gravity of standard gold, which is an alloy of gold and copper in the proportion of 11 : 1.

3. Find the pressure at any point of a liquid at rest, and prove that it increases uniformly with increase of depth below the surface.

A tin vessel shaped like a pyramid on a square base of 12 inches edge is filled with water; the pyramid is 18 inches high, what is the force on the base ?

4. Find the horizontal and vertical pressure on a surface exposed to liquid.

If a solid right cone whose angle is $2a$ be immersed in a liquid with its vertex in the surface and axis vertical, prove that if P be the

whole pressure on the curved surface and base, and P^1 the resultant pressure,

$$\frac{P}{P^1} = \frac{2 + 3 \sin a}{\sin a}.$$

5 Describe a method of removing piles driven down in deep water, explaining the principle involved.

6. Find the conditions of equilibrium of a body floating in a liquid and partly supported by a string, the pull of the string acting downwards.

A uniform rod is suspended by two vertical strings attached to its extremities and half of it is immersed in water. If the specific gravity of the rod be 2·5, the tensions of the strings will be as 9 : 7.

7. If a series of heights be taken in arithmetic progression, show that the densities of the air decrease in geometric progression.

Find an expression for the difference of altitude of two stations.

8. What volume of air at Atmospheric pressure must be introduced into the Toricellian vacuum to depress the column of mercury 5 inches, the area of section of the tube being 1 inch? The barometer originally stood at 30 inches.

9. Describe the common pump.

If the section of the pipe of a pump be 12 square inches, the section of the barrel 1 square foot, and the height of the lower valve above the surface of the water 20 feet, find the length of the stroke that the water may just rise into the barrel at the end of the first stroke.

10. Describe the common hydrometer and its method of use.

A Nicholson's hydrometer weighs 6 ounces, and it is necessary to place weights of 1 oz. and 1½ oz. in the upper cup to sink the instrument to the same point in two different liquids; compare the specific gravity of the liquids.

Geology.

Examiner—Dr. C. J. H. Warden.

1. Explain clearly the arguments which are used to show the age of the earth. Indicate the relative values of the arguments used, and state very roughly the age which these arguments point to.

2. Give a general outline of the chemical constitution of the crust of the earth, and give a classification of the physical conditions in which minerals may occur as constituents of rocks. Give also a description of the physical characters of the four classes, and give examples of your meaning.

3. Describe the physical characters, and give the general chemical composition of the following bodies:—Conglomerate, Trachyte, Ganister, Granite, Dolomite, Rock salt and Oolite.

4. Describe explicitly the phenomena of Geysers, and explain any theories which have been put forward to account for them.

5. Describe clearly what is meant by the "weathering" of rocks. To what active agents is this action due, and how can these actions be explained?

6. Trace clearly the conditions and circumstances of the formation of a glacier, and its history till it finally disappears, (*a*) in high latitudes, (*b*) in the temperate zone, and (*c*) in the tropics. Are glaciers to be found within the Indian area, and if so, under what circumstances?

7. Explain the formation and growth of coral reefs. What are the principal varieties of coral formation? How can the growth of coral reefs be explained?

8. Discuss the formation and origin of the Gangetic Delta. What will be its probable future history?

9. Describe the general structure and arrangement of mineral veins, showing in what manner the contents of a mineral vein may be disposed. What theories have been proposed to account for the infilling of mineral veins?

Mineralogy and Metallurgy.

Examiner—Dr. C. J. H. Warden

1. What is meant by a hemihedral form? Describe some of the hemihedral forms of the cubic system of crystallography, giving as far as possible examples of minerals which exhibit such forms.

2. Describe the crystalline form, general characters, etc., and give the chemical formulæ of the following minerals:—Marcasite, Antimonite, Mispickel, Cassiterite, Magnetite, Muscovite, Selenite and Apatite.

3. Give the principal minerals in which Lead and Silver occur, either separately or together. Give their chemical names and formulæ, their crystalline form and general characters.

4. Describe the principal forms in which Silicon dioxide (uncombined) occurs in nature. Describe each form, giving its physical, crystallographic, etc., characters, and state the circumstances under which each form occurs.

5. Give the composition, chemical formula, crystalline form and general physical characters of the principal chlorides which occur as minerals.

6. Describe in what manner coke differs from coal, and give a description of a coke oven and of the method of working it.

7. Describe the ordinary metallurgical methods for the extraction of Tin from its ores.

8. What are the relative advantages and disadvantages of the Belgian, Silesian and English methods of extracting Zinc from its ores, describing the processes very briefly so as to indicate the above points.

9 Explain and describe the processes employed on a large scale in extracting silver from its sulphuretted ores (excluding argentiferous galena) without the use of mercury, and give the reactions concerned.

DETAILS OF CONSTRUCTION.

Examiner—MR. W. CONNAN

(8 *questions only to be answered.*)

1. Give the brick bond for a 3 brick and 5 brick wall right-angled corner.

2. Note the principles regulating the depth and width of foundations of walls in compressible soils. Give examples.

3. Draw a section of a brick segmental arch 50 feet span, rise one-fourth span, showing thickness of abutment at spring. Note how the latter is arrived at, and show the bond you would use in the brick arching.

4. Write a specification for ashlar stone masonry :—rubble stone masonry : portland cement concrete, all for bridging, and give proportions of materials to be used in each

5. Sketch in detail a good scarf joint suitable for beams subjected to (*a*) tension, (*b*) compression, and a joint suitable to either.

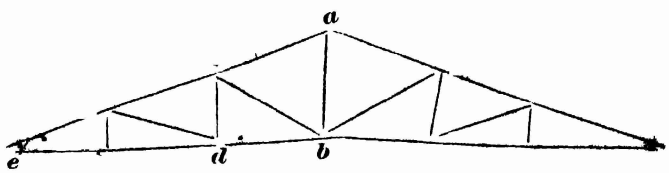
6. Sketch in detail an Iron well curb 18 ft. outside diameter for the foundation well of a masonry bridge pier. The well is 40 feet in depth. Give also a section of the brick well.

7. What precautions would you take with the backing of retaining walls, and how would you allow for drainage?

8. Sketch the joints *a*, *b*, *c*, *d*, *e* in an iron trussed roof, 40 ft. span, 8 ft. rise.

T rafters	4″ × 3½″ × ½″	Tie rod	1¼″ diam.
Struts	3″ × 3″ × ½″	King bolt 1″ diam. Queen rod	

Fig B.



9. What are cofferdams and caissons, and for what class of foundations is each suitable? Give sketches of each.

10. Sketch in detail a pin joint in a warren girder 150 ft. span. Note the weak point in this class of girder.

ROADS AND RAILWAYS.

Examiner—MR. W. CONNAN.

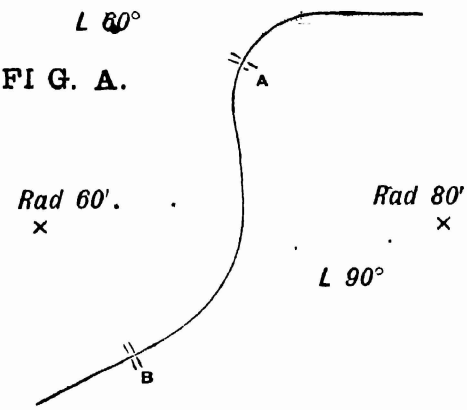
(*Only* 8 *questions to be answered*)

1. Give a specification for the provision and consolidation of stone metal in a first class district road.

2. Shortly summarize the reasons for and against the adoption of an inward slope in the cross section of a hill road 24 ft. breadth, gradient 1 in 24.

3. Draw to scale of 40 feet = 1 inch an S curve (see Diagram) on a mountain road 24 feet breadth, showing provision for drainage along and across road. At (*a*) and (*b*) are two dry stone culverts, 3 ft. span. Hill side bouldery clay, slope 30°. Give cross section. Road gradient 1 in 35.

FIG. A.



4. Note how tractive power is affected by condition of road surface, and give results of any experiments made. Note the maximum gradient permissible for wheeled traffic in a metalled and unmetalled road.

5. Give hand sketches of an economical type of district road bridging for light traffic over flood spill opening 200 ft. long, flood 6 ft. high, country level ground stiff clayey soil.

6. A railway line metre gauge single track is in 20 ft. cutting, through gravelly soil. Give a cross section of line showing permanent way and arrangements for drainage.

7. What fixes the weight of rails to be used in a line? Give examples.

8. Show how the resistance to traction in a level railway is affected by speed, and note the resistance in lbs. per ton for a speed of 20, 40, 60 miles per hour, excluding weight and friction of engine.

9. Sketch a fish-joint showing sleepers and ballast. Note why rails are fish-jointed, and why the sleeper spacing is reduced at joint.

10. If a locomotive can draw itself and a train of empty mineral trucks up a gradient of 1 in 50, what gradient should be adopted to utilize the full locomotive power with trucks fully laden?

HYDRAULIC ENGINEERING

Examiner—MR. G. A. G. SHAWE, A.M.I.C.E.

1. A sluice with two rectangular openings, 8 ft. high by 5 ft. wide, is to be constructed in the embankment of a tidal river, in order to drain a tract of swampy land lying within the embankment. The highest level at which the water stands in the swamp is 11 ft. above the floor-level of the sluice; the L. W. level of the river is 2 ft. above the floor. When the water stands at these levels, calculate the discharge of the sluice.

2. The average velocity through the sluice, obtained by solving question 1, is so high as to endanger the stability of the masonry; and it would not be safe to work the sluice under the conditions given. The highest velocity which can be permitted is 11 ft. per sec., and in order to prevent that velocity being exceeded, a weir or breast-wall is to be built outside the sluice between the wing-walls, at a place where the latter are 25 ft. apart. Of what height should this breast-wall be designed, in order to limit the velocity through the sluice to 11 ft. per sec., the levels of the water in the swamp and in the river being the same as given in question 1? (See descriptive sketch.)

3. A lock-chamber, 120 ft long and 20 ft. wide, with lift of 8 ft., is filled by a culvert opening below the level of the water in the lower reach. Calculate the size of the culvert required to completely fill the lock in 4 minutes. How long will it take to fill the lock to a level 3 ft. below the level of the water in the upper reach?

4. A sluice-opening, 6 ft. square, is pierced in a wall whose face has a batter of 1 in 3. The lower edge of the opening is 12 ft. below the water-surface. The opening is closed by a shutter which rests on the face of the wall and is therefore inclined at the same angle. Find the pressure on the shutter and the centre of pressure.

5. State briefly the laws which govern the friction of liquids.

Assuming that the frictional resistance of an iron ship propelled at a speed of 5 ft. per sec. is 1 lb. on a sq. ft. of submerged surface, what is the resistance in the case of a ship having 2,000 sq ft of submerged surface and propelled at a speed of 18 ft. per sec.? What engine-power is required to drive the ship at that speed?

6. A straight reach of a canal has been dug with a bed-width of 70 ft., side slopes of 1 to 1, depth of water seven feet, and horizontal slope 0·3 per thousand. The co-efficient *c.* as found from Jackson's tables is 0·812. Find the discharge.

7. The accompanying sketch is that of the section of a canal, of which the discharge is to be tested by actual measurement, $\gamma_1, \gamma_2, \gamma_3, \ldots \gamma_7$ are the measured depths at equidistant points on the base; $v_1, v_2, v_3, \ldots v_7$ are the mean velocities, taken with velocity rods at these points, in feet per sec. Give the formula for now calculating the discharge.

8. Required the diameter of a pipe, having a fall of 10 ft. per mile, capable of delivering water with a velocity of 3 ft. per sec. Also give the discharge. The co-efficient of friction for new pipes to be taken.

9. A pipe with an uniform virtual slope of 20 ft. per mile is 18″ diameter from A to B; 30″ diameter from B to C; and 24″ diameter from C to D. (See sketch.) The distances A B, B C, and C D are each one mile. Supposing there is 100 ft. of water above the entrance to the pipe at A, and 48 ft at D, find the probable discharge.

Applied Mechanics

Examiner—Mr W. B. Bestic.

You are not to answer more than eight questions.

The questions are all of equal value.

1. Define the term co-efficient of elasticity, and give examples of different kinds of co-efficients of elasticity, and of their numerical values in materials used in construction.

2. Construct curves of bending moment and shearing force due to a permanent load of 1 ton per foot run on a bridge of 100 feet span, giving the numerical value of each at intervals of 25 feet, reckoned from one abutment.

3. Draw a diagram of forces, and deduce the stress on each part of a simple king-post roof-truss, loaded with 4,000 pounds uniformly distributed. Height of truss = $\frac{1}{4}$ span.

4. A bar 1 inch square, 1 foot long, supported at the ends, carries safely 300 lbs. placed in the middle; what load will a beam of rectangular section, 2 inches broad, 6 inches deep, 4 feet span, carry distributed uniformly?

5. Calculate the moment of inertia of the double-tee section of a rolled iron beam whose extreme depth is 15 inches, web $\frac{1}{2}$ inch thick, flanges $5\frac{1}{2}$ inches wide, and 0·85 inch mean thickness.

6. Explain the terms "extrados," "intrados," "joint of rupture," "line of resistance," used in the theory of arches, and state the conditions of stability of a loaded arch. Being given the intrados and the thickness of the arch at the crown, show how to construct the extrados of the fixed load and of the moving surcharge.

7. Show how to find the pressure of a bank of earth on the back of a retaining wall in the case where the wall is vertical and the earth slopes at its angle of repose. Assuming the thickness of the wall uniform, and treating it as constructed of a series of equal blocks, construct the line of resistance. State the conditions of stability of the wall.

8. Show how to determine the position of resultant pressure on any joint of the abutment of an arched bridge.

9. Sketch a Warren girder of 60 feet span with 5 divisions in the lower boom and find the stress on each part when the centre joint of the upper boom is loaded with 15 tons. Draw in double lines the parts which are in compression.

10. Obtain an expression for the resistance of a circular prism to torsion.

MECHANISM AND THE STEAM ENGINE.

Examiner—MR. G. A. G. SHAWE, A.M.I.C.E.

Do not attempt more than six questions.

1. Sketch the wheel-work and drum of an ordinary hand-crane, to raise about 4 tons, the force applied at the winch-handles being taken at 60 lbs. (Neglect friction.)

2. Give a dimensioned sketch of a claw coupling, suitable for shafts of 6″ diam., and arranged so that the shafts can be disengaged when necessary.

3. If you are set to design a set of speed cones, by which one shaft running at a constant speed is to drive another parallel shaft at different given speeds, how do you determine the ratio of the velocities for each pair of pulleys in the series. Show that, if the belting is crossed, the same belt can be transferred from one pair of pulleys to any other pair, provided only that the sum of the diameters of each pair is the same. Does the same condition apply when an open belt is used?

4. Illustrate by a sketch of an ordinary locomotive slide what is meant by 'lap.' Define 'lead.' If the width of the steam port is $1\frac{1}{4}$ inch, the lap 1 inch, the lead $\frac{1}{8}$ inch, and the travel of the slide $4\frac{1}{2}$ inches; at what point of the stroke will steam be cut off? By what different methods can you increase the amount of expansion in the cylinder?

5. State Boyle's law of the pressure of gases. Show its application by drawing to any scale a normal pressure diagram, such as might be expected from a well-adjusted non-condensing engine, in which the pressure of steam is 75 lbs., length of stroke 1 ft. 6 in. and steam is cut off at 3 inches.

6. If there are two cylinders in the above engine of $9\frac{1}{2}$ inches diamr., and the number of revolutions is 120 per minute, calculate the horse power from the diagram.

7. How would you calculate the area to be allowed for the steam-ports of the above engine? If the engine has the following defects, show by sketches how the diagram taken by an indicator would differ from the theoretically perfect diagram.

(1) if the steam-ports are too small,
(2) if the lead is insufficient,
(3) if the lead is too great.

8. Sketch the following parts of a locomotive:—

(1) Big end of connecting rod.
(2) Ends of boiler, and method of fixing in tube-plate of fire-box.
(3) Top of fire-box, and method of staying.

DRAWING.

Examiner—MAJOR MCARTHUR, R.E.

(*Ten only of these questions should be attempted, unless No. 10 is taken among the number, when nine will suffice to obtain full marks. The figures should be neatly drawn in pencil only, all construction lines being left visible.*)

1. Construct without the aid of a protractor or sector a pentagon of 2 inches side.

2. Make by simple construction a square equal in area to three-fifths of the above pentagon.

3. Construct a simple scale for the above figures, assuming the side of the pentagon to be 1 mile 2 furlongs in length.

4. Construct a comparative diagonal scale, to one of 1 mile = 1 inch, of knots to show decimals of a knot to two places of decimals, 1 knot = 6080 feet.

5. Draw the horizontal and vertical projections of a line:—

(*a*) Inclined 30° to the horizontal plane, and in a plane parallel to the vertical plane.

(*b*) Inclined 30° to the horizontal plane, and in a plane inclined 30° to the vertical plane.

(*c*) Inclined to the horizontal plane at an angle of 45° and in a plane inclined 45° to both horizontal and vertical planes.

6. Draw the vertical and horizontal projections of a tetrahedron whose base is inclined 40° to the horizontal plane and the horizontal projection of one of the sides of whose base is inclined at 30° to the vertical plane.

7. Develop the surface of the above tetrahedron on the horizontal plane.

8. Explain and illustrate by a diagram the principle of isometrical projection. Draw the isometrical scale.

9. On a plane whose traces are inclined to both horizontal and vertical planes, draw the projections of a line inclined at any given angle to the horizontal plane.

10. Assuming the projections of a point above a plane the traces of which are inclined as above and which makes an angle of 30° with the horizontal plane, draw the projections of a line passing through the point and inclined at an angle of 45° to the given plane. Show the point of contact with the plane and of contact with horizontal or vertical plane or with both.

11. Draw the perspective of a cube placed somewhat to the left of the line of sight of the observer, and the prolongation of one of the diameters of which (not a diagonal of a face) passes through the eye of the observer. The distance of object and observer from picture plane may be assumed.

ENGINEER DEPARTMENT.

List of Bachelors and Licentiates in Engineering of the Calcutta University.

	Year.	Present or last appointment
B. C. E.		
Bhut Nath Chattopadhyay ...	1879	Assistant Engineer, East Coast Railway, Madras.
Upendro Nath Chattopadhyay ...	1879	Pleader, Monghyr Bar.
Bama Charan Sen	1880	Overseer, 1st grade, Public Works Department, Chittagong.
Surendro Kumar Bose... ...	1880	Teacher, Civil Engineering College, Seebpore.
Upendro Nath Bandyopadhayay ...	1880	District Engineer, Beerbhoom.
Annadaprosad Sircar	1883	Assistant Engineer, 1st grade, Orissa.
Hari Pada Ghosal	1883	Builder and Contractor, Calcutta.
Rajendranath Mukhopadhyay ...	1883	Overseer, 1st grade, 2nd Calcutta Division.
B. E.		
Sorabji Shavaksha.	1886	Assistant Engineer, 1st grade, Public Works Department, Buxar.
Beni Madhab Mittra	1887	Assistant Engineer, 2nd grade, Public Works Department, Sone Circle.
Nogendro Nath Mukhopadhyay	1888	Assistant Engineer, 3rd grade, Public Works Department, Orissa.
Satish Chandra Chattopadhyay ...	1889	Overseer, 2nd grade, Public Works Department, Singbhoom.
Adhor Lal Chandra	1889	Calcutta Municipal Corporation.
J. B. Godfrey	1890	Temporary Assistant Engineer.
Po Thoung	1890	Practical training.
Khirode Chandra Mukhopadhyay	1890	Ditto.
Haridas Gangopadhyay ...	1890	Ditto.
L. C. E.		
Atul Chander Bandyopadhyay ...	1880	Overseer, 1st grade, Public Works Department, Chota Nagpur, Bengal.
Nogendro Nath Bandyopadhyay	1880	Overseer, 1st grade, Public Works Department, Assam.
Bhabadeb Chattopadhyay ...	1880	Contractor, Madras.
Ashutosh Chattopadhyay ...	1880	District Engineer, Singbhoom.
Gopal Chandra Chattopadhyay ...	1880	Overseer, 1st grade, Public Works Department, Chota Nagpur.
Abhoya Charan Dutt	1880	Calcutta Municipal Corporation.
Jnanendro Nath De	1880	Out of employment.
Bama Charun Mukhopadhyay ...	1880	
Abinash Chander Roy	1880	Supervisor, Public Works Department, Assam.
Radha Raman Guha	1880	Officiating Teacher, Civil Engineering College, Seebpore.
Satya Charan Bandyopadhyay ...	1881	Overseer, 1st grade, Public Works Department, Dacca.
Lalit Mohan Basack	1881	Out of employment.

	Year.	Present or last appointment.
L. C. E.—*continued.*		
T. B. Byers	1881	Temporarily employed in Punjab.
P. W. Byers	1881	Supervisor, District Board, Gaya
Pran Krishna Sen	1881	Overseer, 1st grade, Public Works Department, Orissa.
Bhushan Chandra Bandyopadhyay	1882	Overseer, 1st grade, Public Works Department, Gondock.
Sita Prasanna Roy	1882	Overseer, 1st grade, Public Works Department (Examiner, lightning conductors, Bengal).
Hari Prosad Ghosal	1883	Overseer, 1st grade, Public Works Department, Dacca.
J. A. Martin	1883	Public Works Department, India Government.
C. P. Warde	1883	Assistant Engineer, 1st grade, Public Works Department.
Akhil Chandra Mark	1885	Overseer, 2nd grade, Mohanuddy Division.
Banku Behari Mukhopadhyay ..	1885	Overseer, 1st grade, Public Works Department, Chota Nagpur.
L. E.		
W. A. E. Hanby	1885	Assistant Engineer, 2nd grade, Public Works Department, Bengal Railways.
Hpo Thine	1886	Assistant Engineer, Public Works Department, Burmah.
H. E. W. Martindell	1888	Assistant Engineer, Public Works Department, Burmah.
Hari Charan Mukhopadhyay .	1888	Out of employment.
Surendro Nath Barat ..	1888	Overseer, 2nd grade, Sone Circle.
V. B. Webber	1888	Assistant Engineer, Khidderpore Dock.
Nabakumar Chakrabarti ..	1889	Temporary Teacher, Civil Engineering College.
Gyanendro Nath Gangopadhyay	1889	Temporarily employed, Santipore Municipality.
Krisnadhone Bandyopadhyay ...	1889	Overseer, 2nd grade, Orissa.
Kalibar Bhattacharyya ...	1889	Deceased.
Rajendro Nath Mukhopadhyay ...	1889	2nd grade Overseer, Krisna Nagore.
W. S. Bremner	1889	Assistant Engineer, 3rd grade.
Sarat Chander Sen	1889	Assistant Surveyor, Surveyor-General's office.
Trailokya Nath Mazumdar ..	1890	Practical training.
Nagendra Nath Mittra ..	1890	Ditto.
F. F. Bion	1890	Ditto
Mahendra Nath Datta ...	1890	Ditto
Jadu Nath Das	1890	Ditto.
Bankim Krishna Ghose ..	1890	Ditto.
Abdul Rahman	1890	Ditto.

N.B.—Any inaccuracies in the above list should be brought to the notice of the Principal. Passed students out of employ should register their names and addresses in the Principal's office. It is particularly requested that on any student getting an appointment or changing his appointment, the information be forwarded to the Principal for incorporation in the College Calendar.

ENGINEER DEPARTMENT.

SCHOLARS AND MEDALLISTS.

Forbes' Memorial Scholars.

1880 { Bhusan Chandra Bandyopadhyay.
Kali Gopal Rudra.

1881 Not awarded.

1882 { C. P. Warde.
Hari Pada Ghosal.

1883 W. A. E. Hanby.

1884 { Tarak Chandra Ghose.
Hpo Thine.

1885 Not awarded.

1886 { H. E. W. Martindell.
Hari Charan Mukhopadyay.

1887 { Nogendra Nath Mukhopadyay.
Rajendra Nath Mukhopadyay.

1888 { Adhor Lal Chandra.
W. S. Bremner.

1889 { Mohindra Nath Datta.
Haridas Gangopadhyay.

1890 { Grish Chandra Das.
Modhu Sudan Sen Gupta.

Ambika Charan Chaudhuri Medallists.

1880 Upendro Nath Bandyopadhyay.

1881, 1882 } Not awarded.

1883 Rajendra Nath Mukhopadhyay.

1884, 1885 } Not awarded

1886 Sorabji Shavaksha.

1887 Beni Madhab Mittra.

1888 Nogendro Nath Mukhopadhyay.

1889 Satish Chandra Chattopadhyay.

1890 Khirode Chandra Mukhopadhyay.

APPRENTICE DEPARTMENT.

GENERAL RULES.

1. The College is under the general supervision of a Board of Visitors appointed by the Government.

2. The Principal of the College is charged with the general control of the Institution, including the regulation of the course of study, the supervision of the mess and other domestic arrangements, and the maintenance of discipline; and he will from time to time issue such rules as may be necessary to secure those objects. The workshops are under the control of the Superintendent, and the apprentices while at work in them will be under his orders; but all breaches of discipline will be reported by him to the Principal.

RULES FOR ADMISSION.

3. For admission to the Apprentice Department a candidate must be between the ages of 15 and 17

4. An examination for admission will be held annually at the College on the third Monday in January. Every candidate must apply in writing to the Principal, not later than the 10th January, for permission to appear at the examination, enclosing a certificate of good conduct and a certificate of age. The subjects of examination are—

Arithmetic (the whole).	Euclid (Books I and II).
Algebra to simple equations, inclusive.	English (grammar and composition).

Candidates who have passed by Standard VII of the Code for European schools, or the University Entrance examination in English and Mathematics are admitted without further test.

5. Every applicant, before admission to the College, will be examined by the College Surgeon as to his physical strength, fitness for manual labour, and eyesight. If this officer's report is unsatisfactory, the applicant will not be admitted.

6. Before an apprentice is admitted to the College, his parent or guardian must sign an agreement in the form shown in Appendix A.

7. The session begins on the first Monday in February. All apprentices are required to join the College on that date. Any apprentice prevented by sickness from attending on the opening day must produce a certificate to that effect from a Civil or Assistant Surgeon, failing which he will be liable to a fine not exceeding Rs. 10. No apprentice will be admitted or re-admitted to the College after the close of the month of February, except by special order of the Director of Public Instruction. This permission will only be given under exceptional circumstances. Those students, however, who passed the last Entrance examination will be eligible for admission to the Department up to the first Monday in June.

Course of Instruction.

8. There will be a long vacation from about the middle of August to the end of October. Every apprentice must leave the College during this vacation, and parents or guardians must satisfy the Principal, before their sons or wards can be admitted, that they are able to conform to this rule.

9. The full course of instruction in this class will extend over five years, during the first three and a half of which the instruction will be both theoretical and practical. The last year and a half will be spent entirely in practical work. For details of the course of study *see* Appendix B.

10. Every apprentice who passes the annual examination held at the end of the second year will be entitled, on leaving the College, to a certificate, stating that the holder possesses the theoretical qualifications required of a sub-overseer in the Public Works Department.

11. An apprentice who passes the final examination held at the end of three years and a half will be entitled to a third grade overseer's certificate.

12. On the completion of his practical course, an apprentice will be entitled to a first or second grade overseer's certificate according to the estimate formed of his work by the College authorities. A College certificate gives the holder no claim to a Government appointment.

13. No apprentice who at the end of three years and a half leaves the College with a third grade overseer's certificate will at any further time be allowed to return for his practical course.

14. Every apprentice who leaves the College after the expiration of the five years' course will receive a certificate in the form shown in Appendix C.

[NOTE :—

Extract from the "Calcutta Gazette" of the 16th March 1887, page 79, Part IB.

A candidate for employment on the Subordinate Engineering Staff of the District Engineer must be qualified in one of the manners following, that is to say :—

(1) If the pay of the appointment is Rs. 60 per mensem, or more, he must hold—

(*a*) a certificate from the Principal of the Government Engineering College at Seebpore that he has served his apprenticeship there and passed the final examination qualifying him for employment in the Public Works Department as a Foreman Mechanic or an Upper Subordinate.]

15. Apprentices will attend in the class-rooms and in the workshops in accordance with the College time-table. The hours of work may vary with the seasons of the year.

16. All apprentices will be required to reside on the College premises, so far as the accommodation will permit.

Free and reduced fee list.

17.* European or Eurasian apprentices, up to the number of twenty-five, are received into this Department on payment of Rs. 5

* These rules apply only to apprentices whose parents or guardians reside within the limits of the jurisdiction of the Lieutenant-Governor of Bungal; but the sons of East Indian Railway employés, of soldiers serving in India, and of Survey, Telegraph, and other Government officers who are liable to be employed in Bengal, are admissible to the reduced fee list.

a month for the twelve months of the year. The cost of messing is estimated at Rs. 20 a month. In the case of these twenty-five apprentices, the balance, viz Rs. 15 a month, will be paid to the mess fund by Government. In addition five such apprentices are admitted free Thus the total of free apprentices and apprentices on a reduced fee will be thirty.

18. Europeans and Eurasians in excess of that number will be received as apprentices into the College, so far as the accommodation will permit, on paying the full cost of their messing, viz. Rs. 20 a month. This charge will be payable during the term, reckoned at nine months and a half. During the vacation, taken at two months and a half, a charge of Rs. 2 a month will be made to defray the cost of maintaining mess servants.

19 * Native apprentices up to the number of forty will be received into the apprentice department on payment of Rs. 2 a month for the twelve months of the year. The cost of messing is estimated at Rs. 7 a month. In the case of these forty apprentices, the balance, viz. Rs. 5 a month, will be paid to the mess fund by Government.

20. Native apprentices in excess of this number will be received into the College on paying the full cost of their mess, viz. Rs. 7 a month This charge will be payable during the term, reckoned at nine months and a half. During the vacation, reckoned at two months and a half, a charge of Re. 1 a month will be made to defray the cost of superintendence and mess servants.

STIPENDS.

21. After the final examination, ten stipends of Rs. 10, and ten of Rs. 6 each, tenable for one year and a half, will be awarded to those apprentices who pass the best examination, both theoretical and practical.

STANDING ORDERS FOR STUDENTS.

22. Every resident European apprentice will join the European mess. On joining the mess every apprentice will pay an entrance fee of Rs 10 to the mess fund to provide for the cost of crockery, knives and forks, table linen, &c. A list of breakages and other damage done will be prepared monthly, and each apprentice will be required to pay, by the 15th of the following month, an equal share of the cost. On leaving the mess, if an apprentice has paid all demands, his entrance fee will be returned to him; otherwise it will be forfeited to the mess fund.

23. Hindu apprentices must ordinarily join the College mess for Hindus, and abide by the rules sanctioned by the Principal for the management of their mess Each student on joining the mess will be required to deposit "caution money" to the amount of Rs. 5, which will be ultimately returned to the student if he has not rendered himself liable to the forfeiture of the whole or any part of it.

* These rules apply only to apprentices whose parents or guardians reside within the limits of the jurisdiction of the Lieutenant-Governor of Bengal; but the sons of East Indian Railway employés, of soldiers serving in India, and of Survey, Telegraph, and other Government officers who are liable to be employed in Bengal, are admissible to the reduced fee list.

24. Each resident apprentice must provide his own clothing and bedding and a bedstead. No furniture may be brought into the College without special permission.

25. All payments must be made into the Principal's office on or before the 15th of the month for which the money is due, after which date no payment will be taken unless accompanied by a fine of Re. 1 for every three days of delay. If the payment is not made during the month for which it is due, the defaulting apprentice's name will be struck off the College books, and he will not be re-admitted until he has paid all arrears with fines.

26. The monthly charge for messing may, if necessary, be altered from time to time in reference to the prices of provisions

27. All breaches of discipline committed by any apprentice will be reported to the Principal, who will dispose of them according to the rules and practice of the Education Department

28. A conduct register of each apprentice will be kept by the Principal. The Principal has no power to cancel or alter an entry once made and signed.

29. Apprentices are liable to have their names placed in the conduct register as defaulters for the following offences :—

(I)—Disobedience of orders.
(II)—Absence without leave.
(III)—Idleness.
(IV)—Insubordination or disrespect to the College or workshop authorities.

30. Apprentices may be removed from the College for habitual or gross misconduct, for continued idleness or neglect of work, or for frequent entry in the conduct register. Every such removal should be reported to the Director of Public Instruction, and any fees paid by the apprentice shall be forfeited.

31. Every apprentice will be responsible for any machines, tools, or other articles that may be placed in his charge. He must produce them when called upon to do so, and must at once report any damage done to them. In case of loss or damage arising from carelessness, he may be called upon to pay the cost.

32. A certain number of the apprentices will be appointed monitors, whose duty it will be to assist the College authorities in the maintenance of discipline. For the performance of this duty each monitor will receive a small sum monthly

33. Any monitor may be removed by the Principal for misconduct or for inefficiency in the discharge of his duties.

34. No resident apprentice will ordinarily be allowed to keep a private servant.

35. On Sundays all resident Christian apprentices, Protestant and Roman Catholic, will be required to attend the services held in their respective chapels.

36. All apprentices will be required, while in the workshops, to wear a uniform dress, which will be supplied to them at cost price.

37. Leave will be granted by the Principal only. No leave will be granted except on a written application.

38. No resident apprentice may leave the College premises without the written orders of the Principal, whether on special leave or on a general holiday.

39. All European apprentices will be encouraged to join the Volunteer Corps. Those who join it will be allowed such occasional leave as may be required by the regulations relating to Volunteers.

40. All apprentices are obliged to join the College Athletic Club, the subscription to which is Re. 1-8 per annum, and the entrance fee one rupee.

APPENDIX A.

CIVIL ENGINEERING COLLEGE, SEEBPORE.

Memorandum of the conditions under which _____ *is admitted as a Mechanical Apprentice to the Civil Engineering College, Seebpore.*

1. He will be subject to the regulations set forth in the "Rules of the Mechanical Apprentice Class."

2. He will pay his own travelling expenses to Seebpore.

3. He will be on probation for six months: at the end of which time, if it appears that he is not physically fit for the work, or it for any reason (other than misconduct) it appears inexpedient to retain him, he will be sent back to his friends at the expense of Government.

4. The undersigned _____ will for five years, beginning from the date of admission to the College, provide _____ with suitable clothes and the books required in his class; and will pay in advance to the Principal of the College, on or before the 15th of each month, the sums stated in Rules 19 to 21. He will also make arrangements for the removal of _____ from the College during the long vacation, under Rule 8, or at any other time when required by the Principal.

5. In consideration of the foregoing conditions, _____ will be fed and lodged for a period of five years (excluding vacations), and will receive such instructions as will qualify him for employment as an Upper Subordinate in the Public Works Department and as a Foreman Mechanic.

6. Employment is not guaranteed after completion of apprenticeship.

Signature of parent or guardian { _____

Address. { _____

Signature of witness. { _____

Address. { _____

Signature of the Principal, Civil Engineering College, Seebpore.

Dated the *day of* 189

APPRENTICE DEPARTMENT.

SYLLABUS OF INSTRUCTION.

MATHEMATICS.

Arithmetic—The whole.
Algebra—To end of Binomial Theorem.
Euclid—Books III, IV, VI, and definitions of book V.
Trigonometry—To end of solution of triangles.
Mensuration—Areas of plane surfaces and volumes of simple solids.
Statics—As in Todhunter's Mechanics for Beginners.
Dynamics—Ditto ditto (parts of).
Hydrostatics—As in Besant, Chapters I, II, III, IV, V, and VII.

ENGINEERING.

Building Materials—Carpentry, Masonry, Roads, Buildings. Bridges—Estimating.

APPLIED MECHANICS.

Elementary instruction in the strength of materials and design of structures.

MECHANISM AND STEAM ENGINE.

Elementary forms of mechanical movements—Various parts of engines—Consumption of fuel—Boilers—Forms of valves and valve setting—Indicator diagrams.

NATURAL SCIENCE.

The elements of chemistry—Heat, electricity and magnetism.

SURVEYING.

Surveying with chain, prismatic compass, plane table, theodolite—Levelling—Use of box sextant—Laying out curves.

DRAWING.

Geometrical drawing—Orthographic projection—Engineering and machine drawing—Sketching from models.

APPENDIX B.

Course of Study for the Apprentice Department.

	First year, Feb. to Aug.	Second year, Nov. to Aug.	Third year, Nov. to Aug.	Fourth year, Nov. to Aug.
Mathematics ...	Arithmetic, the whole. Euclid, Books III, IV, VI and definitions V. Todhunter's Algebra to end of Chapter 32, omitting scales of notation. Mensuration.	Algebra to end of Binomial Theorem. Trigonometry. Mensuration.	Statics, Besant's Hydrostatics, Chapters I to IV, inclusive.	Todhunter's Mechanics for Beginners, articles 1 to 50. Chapters VII, VIII, IX, XVII, and article 152. Hydrostatics, Chapters V to VII, inclusive.
Engineering ...	Carpentry	Estimating; Building materials.	Masonry; Estimating, Roads.	Applied Mechanics, Mechanism and the steam-engine, Buildings, Bridges.
Natural Science	.....	Chemistry	Heat	Electricity and Magnetism.
Surveying ...	.....	Surveying with chain and prismatic compass, and Levelling.	Plane Table, Box-sextant, Theodolite and Levelling.	Laying out curves, and Fieldwork generally.
Drawing ...	Printing, Scales, Geometrical drawing.	Orthographic projection ...	Engineering and Machine drawing.	Sketching and Machine drawing.

APPRENTICE DEPARTMENT.

WORKSHOP COURSE.

Workshop Hours, Junior Apprentices 8—11. Senior Apprentices 8—11 and 12-30—4.

First year.

Carpenters' shop.—Apprentices are made acquainted with and shewn how to use and handle properly the tools ordinarily employed for the purposes of carpenters' and joiners' work. They are taught the methods of preparing wood, setting out, and forming the various joints. The practical application of the foregoing instruction is brought to bear by employing them in making stools, boxes, doors, windows, roof trusses and other framings required for buildings and other engineering works.

Second year.

Blacksmiths' and Boiler-makers' shop.—Apprentices are taught to use and handle correctly the different tools, to lay and manage the fires, to draw down, bend, jump, weld, split, punch, chamfer and temper. After this they are set to make small forgings of tools, bolts, nuts, hooks and shackles, and also of parts of trusses, as well as other forgings of parts of machines. In the boiler-makers' shop they are familiarised with the use of riveting tools and the process of riveting, and learn to punch and shear correctly with the machines for that purpose.

Third year.

Vicemen and Fitters' shop.—The apprentices are put through a course of chipping, filing, and fitting so as to gain experience in the tools used by this class of workmen, after which they make up various tools required in the fitters' shop and assist in ordinary fitting work. Those who prove themselves sufficiently proficient are then put on as attendants to the workmen employed on the different machines so as to acquire a knowledge of lathe-work, such as facing, surfacing, turning, boring, and screw cutting, and also shaping, drilling, slotting and planing in the machines used for these purposes. They thus gain confidence in using these machines so as to be entrusted to work them by themselves.

EXAMINATIONS.

Annual examinations are held at the end of the first, second and third years. Each apprentice has to produce within a given time certain tasks allotted him bearing upon the instruction received during the course of the year. These examinations are held personally by the Executive Engineer.

Fourth year.

Foundry or Moulding shop.—Only six months of the apprentices' time is devoted to this shop. They learn to use the various moulders' tools, to mix foundry sand and loam, to make small moulds from patterns supplied, and are shown how to ensure good work and clean castings. They are also taught how to prepare and charge the cupolas. An insight into the nature of the wooden patterns required for forming the moulds being thus obtained, they are set to work with the pattern-makers to make small patterns from which they are expected to produce castings.

EXAMINATIONS.

At the end of the three and-a-half years the apprentices having gone through the various shops have a final examination, and in a given time have to produce pieces of work requiring the use of the different tools used in the respective shops to show that the skill acquired by them has been maintained, and that they show sufficient mechanical aptitude to be considered fit to complete their apprenticeship. During the three and-a-half years theoretical instruction in the College and practical training in the workshops are simultaneously carried on, but during the remaining one and-a-half years they are solely employed in the shops, and are designated "senior apprentices."

Fourth and Fifth years.

Senior Apprentices—Are employed independently on the lathes, drills, shaping, slotting, planing, punching, shearing and screwing machines, and are taught to set out and mark off work for them, these machines being brought into use to make tools machines, parts of engine and pump fittings, and any other instructive work that may be going on in the shops. They assist generally in the repairs to the hulls and machinery of dredgers and launches, also in repairs to portable engines, centrifugal, donkey and other pumps. They are taught to make steam joints, pack glands, set valves, and get up steam and drive engines so as to be competent to take charge of (as well as carry out any necessary repairs to) portable or fixed engines and boilers or a steam-launch. They are also instructed in laying out work to full size on the drawing boards, from drawings, for the use of the workmen.

APPRENTICE DEPARTMENT.

ADMISSION EXAMINATION, 1890.

Arithmetic and Algebra.

1. Simplify $\frac{7\frac{1}{2}}{6\frac{1}{2}} + \frac{11\frac{1}{2} - 2\frac{2}{5}}{11\frac{1}{2} + 2\frac{2}{5}} \times 10\frac{2}{13} - 7\frac{1}{8}$;
and extract the square root of 167 9616

2. The breadth of a room is 14 ft, the cost of papering the walls at 1*s.* per square yard is £4, that of carpeting the room at 4*s.* 6*d* per square yard is £5 12*s.*; determine the height and length of the room.

3. If the price of 100 bricks, of which the length, breadth, and thickness are 16, 8, and 10 inches respectively, be 5*s.* 4*d*, what will be the price of 9,760 bricks which are one-fourth less in every dimension?

4. Find the value of—

$$\tfrac{2}{5}\left(6\tfrac{2}{3} + 2\tfrac{1}{2}\right) £ + \frac{2\frac{1}{4} - \frac{2}{3} \text{ of } 1\frac{5}{6}}{\frac{1}{5} \text{ of } 3\frac{1}{3} + \frac{13}{36}} \times \cdot 95 \text{ of } 5s. + \frac{16\cdot 8}{\cdot 024} d.$$

5. A person contracts to make a railway 189 miles long in 15 months. He employs 129 men; but after 3 months find that he has only finished 28 miles. How many additional men must he employ to finish it within the time required?

6. (*a*) Simplify $\dfrac{1 - \dfrac{2xy}{(x+y)^2}}{1 + \dfrac{2xy}{(x-y)^2}} \div \dfrac{\left(1 - \dfrac{y}{x}\right)^2}{\left(1 + \dfrac{y}{x}\right)^2}$.

(*b*) Divide $\left(\dfrac{x^3}{a^3} - \dfrac{x}{a} + \dfrac{a}{x} - \dfrac{a^3}{x^3}\right)$ by $\left(\dfrac{x}{a} - \dfrac{a}{x}\right)$

7. (*a*) Find the H. C. F. of—

$x^5 - 5x^3 + 5x^2 - 1$ and $x^4 + x^3 - 4x^2 + x + 1$.

(*b*) Find the L. C. M of—

$6(x^2 + xy)$, $8(xy - y^2)$, and $10(x^2 - y^2)$.

8. Solve the equations—

(*a*) $\dfrac{3x+2}{x-1} + \dfrac{2x-4}{x+2} = 5.$

(*b*) $\dfrac{3x + \sqrt{4x - x^2}}{3x - \sqrt{4x - x^2}} = 2.$

(*c*) $\dfrac{a}{bx} + \dfrac{b}{ay} = a + b$, and $\dfrac{b}{x} + \dfrac{a}{y} = a^2 + b^2$.

9. Out of a cask of wine of which a fifth part had leaked away, 10 gallons were drawn, and the cask was two-thirds full. How much did it hold?

GEOMETRY. *Time—2 hours:*

1. Define straight line, right angle, scalene triangle, trapezium, oblong, gnomon, hypotenuse and rectilineal figure.

2. What do you mean by direct and indirect mode of demonstration? What is a converse theorem? Enunciate the converse of Prop. 5, Book I.

3. To describe a parallelogram equal to a given rectilineal figure and having an angle equal to a given rectilineal angle.

4. The diagonals of a parallelogram bisect each other.

5. Enunciate and prove the corollaries of 32nd Prop., Book I.

6. If one side of a triangle be produced, the external angle shall be greater than either of the interior opposite angles.

7. If a straight line be divided into any two parts, the rectangle contained by the whole and one of the parts is equal to the rectangle contained by the two parts, together with the square on the aforesaid part.

8. On what proposition is the rule for finding the square root founded? Prove geometrically that $a^2 - b^2 = (a + b)(a - b)$.

ENGLISH.

1. Give the plurals of the following nouns :—cow, child, phenomenon, locus, story, mouse, index, goose.

2. Give the comparative and superlative of the following :—good, bad, far, little, much, advisable.

3. Give the different meanings of each of the following words and form sentences to illustrate them :—Bear, tense, mine, peer, tart, arch, rail, tender.

4. Parse the words italicised in the following sentences :—

(*a*) His troubles *serve him right.*
(*b*) *To reach* the town, he *must needs pass* this way.
(*c*) *Speaking evil* of others is a practice *to be avoided.*
(*d*) *Speaking* of *this*, what is your opinion?

5. Give the past participles of the following verbs :—meet, tread, speak, shine, shut, weep, rive, derive

6. Correct the mistakes, if any, in spelling, in the following :—dissappoint, embarass, dissatisfied, judgement, January, February, seperate, recieve, tuesday, brief.

7. Correct the following sentences :—

(1) It is for you or I to decide.
(2) The general, with a thousand men, are arrived.
(3) This is a different story to his.
(4) If you are the boy that hast done this, he must be punished.

8. Write a short letter to the principal of your school, asking for leave on account of the illness of one of your relatives.

9. Write a short essay on the advantages of physical exercise.

APPRENTICE DEPARTMENT.

MONTHLY EXAMINATION.

March 1890.

1st year.

1. Solve the following equations:—

(1) $\left(\frac{x-a}{x+b}\right)^2 = \frac{x-2a-b}{x+a+2b}$

(2) $\frac{x}{a} + \frac{y}{b} = 1, \quad \frac{x}{a} + \frac{z}{c} = 1, \quad \frac{y}{b} + \frac{z}{c} = 1$

(3) $ax + by + cz = d \quad a'x + b'y + c'z = d' \quad a''x + b''y + c''z = d''$

Solve the last one by indeterminate multiplier.

2. If $2s = a + b + c$. Prove $(s-a)^3 + (s-b^3) + (s-c)^3 + 3\,abc = s^3$

3. Reduce to its lowest form $\frac{a^3 + b^3 + c^3 - 3abc}{(a-b)^3 + (b-c)^3 + (c-a)^3}$

4. If a straight line be bisected, and produced to any point, the square on the whole line thus produced, and the square on the part produced, are together double of the square on half the line bisected and of the square on the line made up of the half and the part produced.

5. Enunciate the 13th proposition of book II and prove it for an obtuse-angled triangle.

6. Through two given points draw two straight lines forming with a straight line given in position an equilateral triangle.

7. Classify the stones according to their chief earthy constituents, giving two examples of each.

What do you mean by sedimentary and igneous rocks; give examples.

8. For what purposes are the following stones used. Give a short note of their constituents:—Granite, dolomite, oolite, clay slate, trap, soap stone, sand stone, and laterite.

9. Enumerate the principal materials for the preservation of stones.

10. Name the implements which are used in blasting. Explain what you mean by "Line of least resistance."

2nd year

1. (*a*) Show that the angle at the centre of any circle subtended by an arc equal to the radius of the circle is the same for all circles.

(*b*) Show that the circular measure of an angle is equal to a fraction, which has for its numerator the arc subtended by that angle at the centre of any circle, and for its denominator the radius of that circle.

2. (*a*) The sides of a right-angled triangle are in arithmetical progression and the hypothenuse is 20 feet, find the other sides.

(*b*) The three angles of a triangle are in arithmetical progression, and the number of grades in the least : the numbers of degrees in the greatest :: 2 : 9. Find the angles.

3. Sum the series $a + ar + ar^2 + \ldots\ldots\ldots$ to n terms. Find n geometrical means between a and c

4. The sum of £700 was divided among four persons, whose share were in G. P., and the difference between the greatest and least was to the difference between the means as 37 to 12. Find their respective shares

Sum to n terms $r + 2r^2 + 3r^3 + 4r^4 + \ldots\ldots\ldots$

5. Define the following terms:—Natural slope of earth, angle of repose, formation, sidelong ground, half breadths, spoil bank, bench mark, the lead of a cutting or embankment.

6. Describe the two methods of digging into the earth and discuss the advantages and disadvantages of each.

What are side and end-tilt wagons ; in what cases they are used ?

7. On what points does the cost of an earthwork depend ?

8. Describe the operation of boring, and name the tools used in it.

9. Distinguish clearly between chemical and physical actions. Give four examples of each.

10. State some of the more-important methods of preparing oxygen; and point out those which are generally used in practice.

11. Give the most characteristic test of oxygen. What is the chemical signification of the word 'combustion'? Give examples.

12. How is ozone most conveniently obtained. ? Contrast the more important properties of oxygen and ozone.

3rd year.

1. How does heat affect matter? Give examples.

2. Distinguish clearly between heat and temperature. How is heat most commonly measured ? Describe as fully as you can the construction of a tolerably accurate mercurial thermometer.

3. What temperature is the same numerically both on the centigrade and Fahrenheit scales ?

4. Describe Phillips' "Maximum Thermometer" and Leslie's "Differential Thermometer." How is the former set again after an observation?

5. Explain fully how forces are represented geometrically.

6. Enunciate and explain the principle of transmissibility of force.

7. (*a*) Enunciate the parallelogram of forces; the triangle of forces, and its converse.

(*b*) If three forces acting at a point keep it in equilibrium, then each force is proportional to the sine of the angle between the directions of the other two.

8. Assuming the truth of the parallelogram of forces for the magnitude of the resultant, prove it for the direction.

9. Give sketch of a king-post truss with the names of the several pieces of timber used in it.

10. Give sketch of the junction of the foot of the principal rafter with the end of the tie beam, and of the struts with the king-post.

11. (*a*) What is meant by the neutral axis of a beam?

(*b*) Show how you would scarf a beam subjected to transverse strain, and give reasons for your answer.

12. How would you determine the length that must be left between the foot of the principal rafter and the end of the tie beam, in order that it may safely resist the tendency of the horizontal component of the thrust of the rafter to shear it off?

4th year.

1. State the laws of electric force; and describe briefly an apparatus by which you can approximately verify their truth.

2. Explain clearly what you mean by "Electric Induction." Describe the action of the electrophorus and also of Ramsden's Plate machine, stating briefly the more important points.

3. A body starting with velocity V_0 is acted on by a uniform force in the direction of its motion; if f be the acceleration and s the space described in the time t, then $s = V_0 t + \frac{1}{2} ft.^2$.

The time of falling from rest down a chord of a vertical circle drawn from the highest point is constant.

4. State the conditions of equilibrium of a floating body.

A body floats in a liquid with $\frac{3}{4}$ths of its volume immersed, and in another with $\frac{4}{5}$ths immersed; compare the specific gravities of the two liquids.

5. Explain the following terms:—Strain, Stress, Live load, and Factor of safety.

What are the principal modes of applications of loads to a structure; illustrate by diagrams.

6 What is the chief fundamental formula for finding the breaking weight of a piece under direct load. Explain the reason why the same formula cannot be used for pieces of greater length in compression? And state the modified formula for pillars as used by Gordon.

7. Give sketches of different kinds of pillars that can be made from wrought iron. For hollow cast-iron pillar which is taken as least breadth for calculation?

8. Find out the working load on a teak pillar of square section 16 feet high, 6·5 inches broad, both ends fixed, $s = 10$, $f_c =$ 12,000 lbs.

9. Name the principal elements of a steam engine and describe their arrangement adopted in practice.

Mention the various purposes for which the steam engine is employed.

10. Explain the action in distributing steam by an ordinary slide-valve.

What is the use of the fly wheel in a steam engine?

11. Mention some of the most obvious advantages and uses of machinery and the various means by which forces, applied to give motion to machinery, are developed.

12. Name and classify the important parts of a machine according to the purpose they serve.

MAY 1890.

1st *Year.*

1. Give the dimensions of English bricks. What should be the size of the mould for these bricks?

2. What precautions would you take in burning a kiln? What is the effect of rain upon kacha bricks?

3. State the advantages and disadvantages of kilns over clamps, with your reasons.

4. What do you understand by annealing? What is its object? What precautions would you take to anneal bricks? State the advantages and disadvantages of coal as brick-burning fuel over wood.

5. The opposite angles of any quadrilateral figure inscribed within a circle are together equal to two right angles.

6. State and prove the converse of the preceding proposition.

7. From a given point outside a circle draw a straight line touching the circle.

8. The middle point of the hypothenuse of a right-angled triangle is equidistant from the three angular points of the triangle.

9. Extract the square-root of :—

(i) $7\sqrt{3} - 12$ (ii) $\sqrt{80} + 2\sqrt{15}$

10. Find x in the following equations :—

(i) $x^2 + c^2 - d^2 - 2cx = 0$ (ii) $\frac{x+2}{x-2} - \frac{x-2}{x+2} = \frac{5}{6}$

2nd year.

1. What is the difference between a chemical compound and a mechanical mixture? Are N and O chemically combined or mixed together in air?

2. Express in equations what happens (*a*) when copper and dilute nitric are mixed together, (*b*) and when copper nitrate and strong sulphuric acid are heated together.

3. How much nitre is required to produce 50lbs of HNO_3?

4. State Dalton's atomic theory.

5. Explain the following terms:—Side-cuttings, Spoil-bank, Horse-run, and Casting up by stages.

6. Sketch and describe the different sorts of drains used to carry off the surface water of an embankment or a cutting.

7. Describe the three methods of making an embankment, and discuss the advantages and disadvantages of each.

8. Describe the process of puddling the bank of a canal dug out in a non-retentive soil, a part only of the bank being of made-earth.

9. (*a*) Trace the changes in the sign and magnitude of the secant of an angle, as the angle increases from 0° to 360°

(*b*) Find the trigonometrical ratios for an angle of 30°.

10. Prove that—

$$(a) \quad \cot^2\frac{\pi}{4} - \cot^2\frac{\pi}{6} = \frac{\sin^2\frac{\pi}{6} - \sin^2\frac{\pi}{4}}{\sin^2\frac{\pi}{4} \times \sin^2\frac{\pi}{6}}$$

(*b*) From the top of a hill there are observed two consecutive milestones, on a horizontal road, running from the base. The angles of depression are found to be 45° and 30°. Find the height of the hill.

11. (*a*) Prove that reciprocals of quantities in H. P. are in A. P.

(*b*) Show that b^2 is greater than, equal to, or less than ac, according as a, b, c, are in *A. P.*, *G. P.*, or *H. P.*

12. (*a*) Show that the number of combinations of n things ak en r at a time is the same as the number of them taken n—r at a ime.

(*b*) From a company of soldiers mustering 96 a picket of 10 is to be selected; determine in how many ways it can be done. (1) so as always to include a man, (2) so as always to exclude the same man.

3rd year.

1. The length of a bar of steel at 30° C is 1,000; find its length at 50°. The coefficient of linear expansion of steel = ·0000114.

2. The volume of a glass vessel is 100 at 0° and 100·254 at 100°C; find the coefficient of cubical expansion of glass. Describe a peculiarity in the expansion of water.

3. Express in equations what happens (*a*) when solutions of K_2CO_3 and lime water are mixed together; (*b*) when solutions of K_2CO_3 and calcium nitrate are mixed together.

4. Describe how KHO is prepared from K_2CO_3.

5. Forces act on a particle in one plane: required the magnitude and direction of the resultant.

The circumference of a circle is divided into any number of equal parts; forces are represented in magnitude and direction by straight lines drawn from the centre to the points of division; show that these forces are in equilibrium.

6. To find the magnitude and direction of the resultant of two unlike parallel forces acting on a rigid body.

A man supports two weights slung in the ends of a stick 40 inches long placed across his shoulder; if one weight be two-thirds of the other, find the point of support, the weight of the stick being neglected.

7. Two unlike couples will balance each other, if their moments are equal.

8. The algebraical sum of the moments of two forces round any point in the plane containing the two forces is equal to the moment of the resultant.

9. Describe a terrace roof with the usual dimensions.

10. Define gabled end and hipped roofs, Pitch of a roof, Purlins, Queen post, Straining beam.

11. Sketch a King post truss, 30 feet span, showing the joints clearly.

12. You have got sufficient sâl sleepers, each being 10 feet in length, at your disposal; you are required to construct a centering for a bridge over a jungle stream, the breadth of which is 15 feet. The bank of the stream is very hard and unyielding, but the bed is too treacherous to be relied upon; give the sketch of your arrangement so that you can dispense with intermediate posts for the support of the centering.

4th year.

1. Sketch and name all the parts of the cylinder of a steam-engine, showing the slide-valve in one of its positions.

2. Mention the two ways in which a governor acts upon the steam supply for regulating the speed of an engine. Sketch and explain the action of the most common form of governor used in the steam-engine.

3. The angle between the directions of the axes of two rods is 60° and the velocity ratio is 2 : 3. Design a bell-crank lever, joining the two rods, to transfer motion from one to the other.

4. Mark the direction of motion of a belt passing over two pulleys whose axes are at right angles to each other, and state the rule to be observed, in this case, so as to keep the belt always working upon the pulleys.

5. Why should a large number of cells be required to produce the electric light?

6. Find the resistance of a wire whose length is 500, section 20, and specific resistance ·05, *or*, explain the construction of a galvanometer.

7. A body is projected vertically upwards with a velocity which will carry it to a height $8g$, find this velocity.

8. The air contained in a cubical vessel, the edge of which is one foot, is compressed into another the edge of which is one inch, and the temperature is raised by 100°; compare the pressures on a side of each vessel.

9. Find by graphical method the stresses on the bars of a King post truss, span is equal to 30 feet, inclination of the rafter to the horizon is 30,° the vertical load is 40,000 lbs.

10. Show by sketch how to find the stresses for wind pressure in Question 9, and explain how one strut remains unstrained.

11. Define a Truss and polygon of loads.

12. Draw only the polygon of loads in a Queen post truss; the vertical load is W lbs.; extra single load at the ridge pole is w, and two detatched single loads w^1 at the two Queen joints.

JUNE 1890.

1st year.

1. Describe the ordinary process of tempering the clay.

2. Describe the blunging process.

3 Give Vicat's division of limes.

4. How would you manufacture hydraulic cement from pure limestone?

5. The angle in a semicircle is a right angle.

6. Prove the 36th proposition of Book III.

7. If the opposite sides of a quadrilateral are equal, it is a parallelogram.

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8. Construct a right-angled triangle, having given the perimeter and an angle.

9. Form the quadratic whose roots are $c \pm d$.

10. Find x in $3\,x^n\sqrt[3]{x^n} + \frac{2\,x^n}{\sqrt[3]{x^n}} = 16$.

11. Find the sum, difference, and the product of the roots of $x^2 - 26x - 120 = 0$.

12. If α and β be the roots of $x^2 - p\,x + q = o$, form the equation whose roots are $\frac{1}{\alpha}$ and $\frac{1}{\beta}$.

2nd year.

1. What changes do you see (*a*) when carbonic oxide is passed over heated cupric oxide, (*b*) when a mixture of charcoal and cupric oxide are heated together?

Give also the reactions which take place.

2. How can you show that CO_2 is produced by heating chalk? How much quicklime can be produced from 100 lbs of chalk?

3. Describe the properties of CO_2.

Explain the blue flame noticed above a mass of burning hard coal.

4. What are the chief products in the destructive distillation of coal? What is the composition of coal gas? How is coal gas purified?

5. Define the following terms:—Builds, courses, batter, facing, backing, filling, quarry pitched, under-pinning, open joint, and over-flashed joint.

6. Describe the four kinds of stone masonry, clearly stating the points of resemblance and difference in each.

7. (*a*) Explain why the use of longer stones in the body of a wall is objected to, and why the same kind of stones is useful for coping?

(*b*) Sketch and explain the use of the different kinds of lewis used in hoisting stones.

8. Explain the construction and use of an American Derrick-crane?

9. In the expansion of $(1 + x)^n$, prove that the co-efficient of the rth term from the beginning is equal to the co-efficient of the rth term from the end.

10. Write down the (r + 1)th term of $(x + a)^n$.

" " 3rd " " $(a + b)^{15}$.

" " middle term " $(a + x)^{10}$.

" " " " " $(a + x)^{9}$.

11. Prove the following relations :—

$\text{Cos}\, x + \sin x . \tan x = \sec x.$

$(\text{Cos}^2\, \theta - 1)\, (\cot^2 \theta + 1) = -1.$

$\text{Cot}^2\, a - \cos^2 a = \cot^2 a \cos^2 a.$

$2 \text{ versin } \phi - \text{versin}^2 \phi = \sin^2 \phi.$

12. Express the other trigonometrical ratios in terms of the secant.

Given $\tan a = \frac{a^2}{b^2}$, find cosec a and sec a.

" versin $\theta = \frac{1}{13}$ " $\sin \theta$ and sec θ.

" $\cos \theta = \frac{20}{101}$ " $\sin \theta$ and $\tan \theta$.

3rd year.

1. If at the temperature of 32° C. a gas has a pressure of 30 inches of mercury, what will be its pressure at the temperature of 100°C, the volume remaining constant?

2. Do bodies expand or contract on melting? Give examples.

How is a tire made to fit on a wheel?

3. State what happens, giving reactions which take place, (*a*) when limestone is strongly heated, (*b*) when a mixture of limestone, coal dust, and salt cake are heated together, (*c*) when black ball is lixiviated with water.

4. Describe briefly the preparation of soap.

5. Find the quantity of masonry in the annexed culvert.

6. Find the conditions of equilibrium of a system of forces acting in one plane on a rigid body.

7. Find a point within a quadrilateral such that if forces be represented by straight lines drawn from it to the angular points the forces will be in equilibrium.

8. Find the condition of equilibrium of a constrained body.

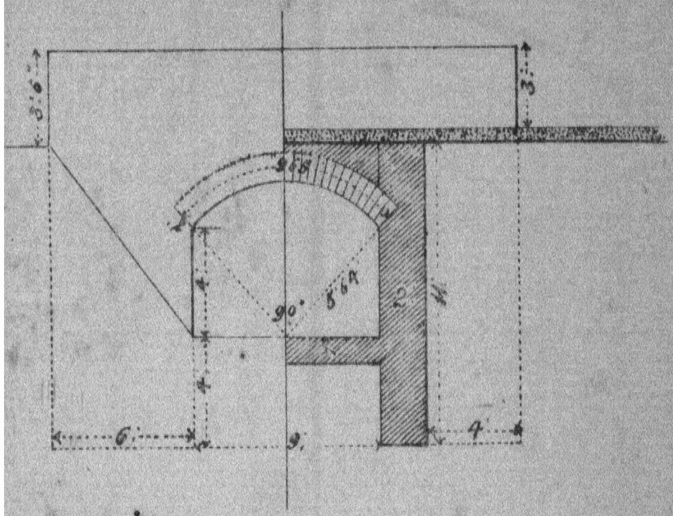
9 Deduce the formula $\bar{x} = \frac{\Sigma P x}{\Sigma P}$ for centre of parallel forces.

Explain why the same formula can be applied in finding the centre of gravity of a body.

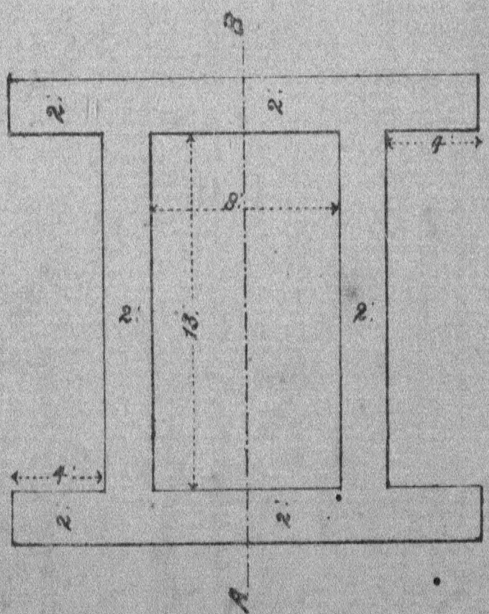
(*b*) Parallel forces P Q R act at the angular points A B C of a triangle, show that the perpendicular distance of their centre from the side B C is $\frac{P}{P + Q + R} \times \frac{2 \text{ area of triangle}}{B\,C}$.

ESTIMATING

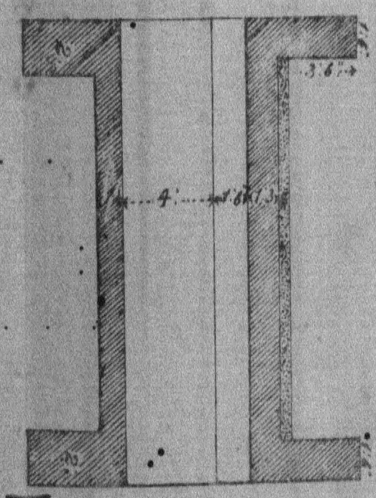
Half Elevation & Section.



Scale 8 feet = 1 Inch.



Plan.



Section on A.B.

4th year.

1. (*a*) Explain the action of the simplest form of *D* slide valve driven by a single eccentric.

(*b*) Sketch an ordinary *D* valve with inside and outside lap, placing the valve on the face of the steam ports to show the lead.

2. Describe the mode of varying the rate of expansion and of reversing by means of Stephenson's link-motion.

3. Sketch and explain the use of friction-wheels.

4. Construct the curve of a cam so that the velocity of the rod moved by it may increase or decrease, as the case may be, according to an arithmetical progression, the angular velocity of the cam being constant.

5. Explain briefly the construction and operation of the telephone.

6. Is heat a form of energy? Give reasons for your answer.

Find the kinetic energy of one pound of matter when it has fallen through 18 feet.

7. A weight M is drawn up a smooth plane inclined at an angle of 30° to the horizon by a weight $2M$. Find the acceleration and the space described in one second from rest.

8. State the principle of the construction of a forcing pump.

9. Define bending moment, shearing force, cantilever. (*b*) Show by sketch the different kinds of internal stresses produced in a beam transversely loaded.

10. Find the scantling of *sâl* beams to carry a terrace roof 16 feet × 18 feet. There are 5 beams 3 feet apart, centre to centre; weight of the roof 1 cwt. per square foot.

11. Find the maximum bending moment and maximum shearing force on a 20 feet girder uniformly loaded with a load of $1\frac{1}{3}$ tons per foot run.

Find the same at 3 feet from one end.

12. Show how the areas of the flanges and web of the girder can be found What particular consideration is to be made in finding the area of a tension flange; why is the same consideration not necessary for compression flange.

JULY 1890.

1st year.

1. State Vicat's divisions of artificial hydraulic limes. What is the effect of mixing soorkee with kunkur lime in forming mortar?

2. State the chief points to be attended to in applying mortar

3. Why is sand mixed with mortar? What sand would you prefer for the purpose?

4. What is the object of plastering? Describe Madras chunam.

5. Prove the 10th proposition of Book IV.

6. Describe a circle about a regular heptagon.

7. If the diagonals of a parallelogram are equal it is a rectangle.

8. Two sides of one triangle are equal to two sides of another triangle, and the included angles are supplementary; the triangles shall be equal in area.

Solve the equations—

9. $x + y = 8$; $x^3 + y^3 = 152$.

10. $x^2 + 2xy + 2y^2 = 34$; $2x^2 - xy + y^2 = 11$.

11. What are eggs a dozen when two more in a shilling's worth lowers the price one penny a dozen?

12. A man bought a certain quantity of wine for £10, of which five gallons leaked out; he recovered the loss by raising the price 8*d.* per gallon; how much wine did he buy?

2nd year.

1. How is *Cl* obtained from ammonium chloride? State the reaction which takes place. How much *Cl* can be obtained from 100 lbs. of ammonium chloride?

2. Describe the changes which you perceive, and also state the reactions which take place—(*a*) when chlorine water is added to a solution of potassium iodide, (*b*) when common salt and sulphuric acid are heated together, (*c*) when sulphur is heated in air.

3. Describe the properties of *Cl* and explain its bleaching action.

4. Write down the formulæ of barium chloride, calcium sulphite, and ammonium bromide.

What is the most important property of H F?

5. Explain the following terms:—

The bond in brickwork, closers, headers, stretchers, standards, ledgers, putlogs and racking back.

6. Name and describe the two modes of bonding brickwork, and discuss the advantages and disadvantages of each.

7. Show by sketches the modes of arranging bricks in English and Flemish bond where one wall of 1½ bricks thick meets another at right angles.

8. What precautions must be taken to diminish as far as practicable the danger from unequal settling in the parts of a wall?

9. Define the following terms:—

An integer, a power of a number, indices, homogeneous expressions, literal coefficients, numerical coefficients, absolute value of a quantity, an equation, an identity, and roots of an equation.

10. (1) If $x + y + z = O$ shew that $x^3 + y^3 + z^3 = 3xyz$.

(2) Simplify $\frac{1}{x^2 - y^2} + \frac{1}{(x + y)^2} - \frac{1}{(x - y)^2}$.

(3) Resolve into factors $a^2 (b + c) + b^2 (c + a) + c^2 (a + b) + 2 abc$.

(4) Solve the equation $\frac{a + b}{x - c} = \frac{a}{x - a} + \frac{b}{x - b}$.

11. Given that the sine of an angle is $\frac{a}{b}$; construct the angle.

Given that the cosine of angle is $\frac{a}{b}$; construct the angle.

12. Prove that—

(1) $(\text{Sec } \theta - \text{cosec } \theta)(1 + \cot \theta + \tan \theta) = \frac{\sec^2 \theta}{\text{cosec } \theta} - \frac{\text{cosec}^2 \theta}{\sec \theta}$.

(2) $\cos x (2 \sec x + \tan x)(\sec x - 2 \tan x) = 2 \cos x - 3 \tan x$.

(3) $(\text{cosec } \theta - \cot \theta)^2 = \frac{1 - \cos \theta}{1 + \cos \theta}$.

(4) $\frac{1 + (\text{cosec } \theta \times \tan \phi)^2}{1 + (\text{cosec } a \times \tan \phi)^2} = \frac{1 + (\cot \theta \times \sin \phi)^2}{1 + (\cot a \times \sin \phi)^2}$.

3rd year.

1. Define the boiling point of a liquid. On what circumstances does this depend?

In what respects does a vapour in contact with its own liquid differ from a gas?

2. Describe and explain the spheroidal state of liquids.

3. How is alum manufactured? Describe the tests of aluminium salts.

4. How are fast colours produced with alum? Explain the process of glazing earthenware vessels.

5. Explain the following terms:—Trimmers, freize rail, styles, lintel, going of the flight, dog-legged stairs, carriages, well hole, newel stairs.

6. Describe a bridging joisted floor with sketches.

7. What are the ordinary methods of arranging the opening of windows? Describe them clearly.

8. Describe the different kinds of stairs with sketches.

9. Find the centre of gravity of a triangle.

A quarter of a triangle is cut off by a straight line parallel to one of its sides, find the C.G. of the remaining piece.

10. When a body is placed on a horizontal plane, it will stand or *fall according as the vertical line drawn through its C.G. passes within or without the base.*

The height of a right cone is h, radius of the base is b. It is placed on a rough plane. To what angle must the plane be raised so that the cone will just topple over?

11. Define a lever and classify them, giving examples of each.

If the pressure on the fulcrum be 5 lbs, and one of the weights be distant from the fulcrum one-sixth of the whole length of the lever, find the weights, supposing them on opposite side of the fulcrum.

12. Graduate a common steel yard.

4th Year.

1. Prove the formula $P = \frac{w}{2} h^2 \tan^2 \frac{a}{2}$ where P = Horizontal thrust of a wall, w = weight of a cubic foot of earth, h = the height of the wall, a = the angle which the line of natural slope makes with the vertical.

2. Explain by diagrams the maximum, mean and minimum intensities of pressures; show their relations also.

3. Explain how the breadth of a retaining wall is calculated. What practical considerations regulate its design?

4 A revetment 30 feet high, 3 feet thick at top, 6 feet thick at bottom with counterforts 20 feet apart, the breadth of counterforts being 4 feet, find the lengths of these counterforts.

5. What do you mean by face and back batter? What is the object of giving these batters? Why do the courses of masonry in these walls always incline from front to rear?

6 If a body of weight W be dragged up a rough plane inclined to the horizon at an angle a and through a space S, and if M be the coefficient of friction for motion; find the work done.

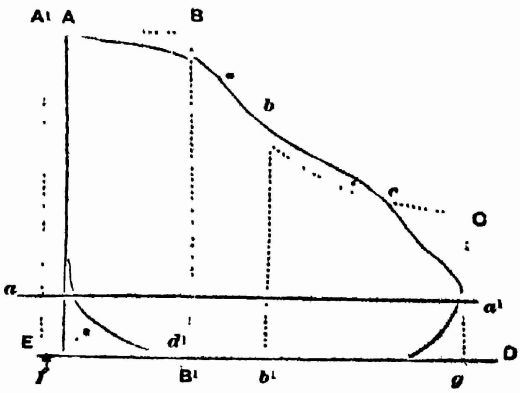
Prove that the kinetic energy of a body $= \frac{mv^2}{2g}$.

7 A Nicholson's hydrometer weighs 6 oz., and it is requisite to place weights of 1 oz. and $1\frac{1}{2}$ oz. in the upper cup to sink the instrument to the same point in two different liquids; compare the specific gravities of the liquids.

8 1·6 lbs of a metal at a temperature of 100°C are mixed with 6 lbs. of ice-cold water and the common temperature is then found to be 10°C, what is the specific heat of the metal?

9. Describe and explain the action of a Grove cell.

10 Point out and explain all the peculiarities and defects of the annexed indicator diagram taken from a fairly well constructed engine, as compared with the ideal diagram.



11. Sketch a Lancashire boiler, showing all the parts and fittings complete.

12. What do you understand by the term self-feeder as applied to a machine Sketch and explain the self-feeding arrangement in an ordinary saw mill.

13. Sketch and explain the mechanism of the hand jack.

AUGUST 1890.

1st year.

1. What is the object of seasoning timber? Describe the artificial methods of seasoning timber, stating the advantages and disadvantages of each method.

2. Describe Bethell's method of preserving timber.

3. Where do the following trees grow, and for what works are they generally used:—

Jámoon, babool, teak, sâl, deodar, bamboo, and ebony.

4. Name the principal avenue trees.

5. Divide 111 into three parts so that the products of each pair may be in the proportion of 4, 5 and 6.

6. If x varies jointly as y and z, and y varies directly as $x + z$, and if $x = 2$ when $z = 2$, find the value of z when $x = 9$.

7. The value of a diamond varies as the square of its weight; a 4-carat diamond is worth £1,000, find the value of one that weighs 6-carats.

8. Each of two vessels contains a mixture of wine and water; a mixture consisting of equal measures from the two vessels contains as much wine as water, and another mixture consisting of four measures from the first vessel and one from the second is composed of wine and water in the ratio of 2 : 3. Find the proportion of wine and water in each of the vessels.

9. Prove proposition III of Book VI.

10. Define similar figures: Prove that equiangular triangles are similar.

11. The straight line joining the middle points of the sides of a triangle is parallel to the base.

12. Prove proposition II of Book VI. The first part only

2nd year.

1. What are the particular points that must be observed in providing a firm foundation bed, so as to ensure strength and durability in the structure to be built on it.

2. (*a*) Classify soils with respect to foundation.

(*b*) Describe one of the methods for providing a firm foundation bed in marshy soil.

3. Sketch and name the different descriptions of files and mention their use.

4. Describe the process of well-sinking; illustrating your description by sketches.

5. (1) $\frac{x}{a} + \frac{y}{b} = 1, \quad \frac{x}{3a} + \frac{y}{6b} = \frac{2}{3}$

(2) $\frac{x}{a+b} + \frac{y}{a-b} = 2a, \quad \frac{x-y}{4ab} = 1$

(3) $\frac{x}{a} + \frac{y}{b} = 1, \frac{x}{a} + \frac{z}{c} = 1$, and $\frac{y}{b} + \frac{z}{c} = 1$

6. Prove that—

(1) Sin (90°—A) = cos A.

(2) Cos (90°+A) = — sin A.

7. Show that cos (A—B) = cos A. cos B + sin A. sin B.

8. (*a*) Find a value of θ which will satisfy the following equations—

(1) Sin θ + cos θ = $\sqrt{2}$.

(2) $\sqrt{3}$ sin θ = $\sqrt{3}$ — cos θ.

(*b*) Write down the general value of θ which satisfies the following equation—

$3 \sin \theta = 2 \cos^2 \theta$.

9. Describe the decompositions by which sulphuric acid is manufactured in the leaden chamber?

How would you detect the presence of sulphuric acid?

10. Describe what happens -

(*a*) When dilute H_2SO_4 is mixed with ferrous sulphide.

(*b*) When H_2S is passed through an acid solution of arsenic chloride.

11. (*a*) How much H_2SO_4 will be neutralized by 100 grains of KHO?

(*b*) How much arsenic is contained in 10 grains of white arsenic?

12. Write down the formulæ of calcium phosphate, ammonium sulphide, silver sulphate, and acid sulphate of sodium. What is the composition of quartz?

3rd year.

1. Describe the wheel and axle, and find the condition of equilibrium. If the string to which the weight is attached be coiled in the usual manner round the axle, but the string by which the power is applied be nailed to a point in the rim of the wheel, find the position of equilibrium, the power and the weight being equal.

2. In the system of pulleys in which each string is attached to the weight, and all the strings are parallel, when there is equilibrium, find the ratio of P to W, *n* being the number of *moveable* pulleys:

If a man support a weight equal to his own, and there are three pulleys in the first system, find his pressure on the floor on which he stands.

3. State the laws relating to the extreme amount of friction that can be brought on a surface. Define the coefficient of friction and the angle of friction. Prove that the coefficient of friction is equal to the tangent of the inclination of the plane when the body is *just* about to slide.

4. A railway train weighing 30 tons is drawn up an incline of 1 foot in 60 feet length by means of a rope from a stationary engine. Find the least number of pounds the rope should be able to support.

5. Define curve of equilibrium. Explain how this can be drawn in an arch ring.

6. State the formulæ given by Rankine to find the horizontal thrust of an arch ring; and show by taking moments how to find the thickness of abutment.

7. Describe the construction of an oblique arch.

8. (*a*) What are the permanent adjustments of an Everest Double Arc Theodolite?

(*b*) The primary scale reads to 10 minutes; looking into the instrument it is seen that 40 divisions of the vernier cover 39 divisions

of the primary: find the graduation of the vernier, and how much can you read by this instrument?

9. (*a*) How is it that a piece of ice may be kept from melting for a long time by wrapping it in a blanket?

(*b*) If there are two bars, one of bismuth and the other of iron, in which will the rise of temperature travel more quickly?

Give reasons for your answer.

10. Account for the existence of trade winds and show how the rotation of the earth affects their direction:

11. Define the specific heat of a substance. A piece of hot platinum 3·6 lbs. in weight is plunged in 6 lbs of ice-cold water, if the common temperature is found to be 20°C find the initial temperature of the platinum. The specific heat of platinum = ·036.

12. How would you distinguish metallic zinc from tin?

APPRENTICE DEPARTMENT.

ANNUAL EXAMINATION JANUARY 1890.

Arithmetic and Algebra.

1st, 2nd and 3rd years.

1. Simplify $\dfrac{2\frac{7}{9} - 9\frac{2}{5} \times 8\frac{1}{3} + 1\frac{1}{24}}{1\frac{17}{18} \times 5\frac{5}{14} - 3\frac{4}{27} \times 3\frac{4}{17}} \div \dfrac{7\frac{4}{15} - 1\frac{1}{5}}{13\frac{1}{3} - 4\frac{2}{13}}$.

2. Divide 195·3125 by ·05005, and multiply ·37592 by ·05.

3. Find by "Practice" the value of 5 cwt. 2qrs. 14 lbs. at £2 5*s*. 6*d*. per cwt.

4. Find the simple interest on £556 13*s*. 4*d*. for six years at 5 per cent.

What sum of money lent out at 5 per cent. per annum, simple interest, will produce in four years the same amount of interest as £250 lent out at 3 per cent. per annum, in six years.

5. A person transfers £3,000 stock from the 3 per cent. consols at $89\frac{3}{4}$ to the reduced $3\frac{1}{2}$ per cents. at $98\frac{1}{4}$. Find what quantity he will hold, and the alteration in his income.

6. Simplify $\left\{ (a^{\frac{4}{3}}\ b^{\frac{3}{4}})^{-\frac{1}{2}} \times (a^{-\frac{3}{4}}\ b^{-\frac{4}{3}})^{\frac{1}{2}} \right\}^{-24}$

7. Solve $\dfrac{a}{x-a} + \dfrac{b}{x-b} = \dfrac{2c}{x-c}$

8. If a and b be the root of $x^2 - px + q = o$. Find the value of $\dfrac{a}{b} + \dfrac{b}{a}$ and of $a^3 + b^3$.

9. Sum the series—(1) $5 + 6{\cdot}2 + 7{\cdot}4 + 8{\cdot}6 + \ldots$ to 21 terms; (2) $5 + 1 + {\cdot}2 + {\cdot}04 + \ldots$ to infinity, and insert three harmonical means between 1 and $\frac{1}{20}$.

10. Given that x varies directly as $y + \dfrac{1}{y}$ and that $x = 202$ when $y = 10$. Find x when $y = 5$.

Given that the volume of a sphere varies directly as the cube of its radius; prove that the volume of a sphere whose radius is 6 inches = the sum of the volumes of three spheres whose radii are 3, 4, 5 inches.

11. If $\dfrac{a}{b} = \dfrac{c}{d}$, prove that $\dfrac{a+b}{c+d} = \dfrac{a-b}{c-d}$, and that $\dfrac{ma+nb}{pa+qb} = \dfrac{mc+nd}{pc+qd}$

12. Expand $(x + a)^8$; and find the $(r + 1)$th term of $(1 - nx)^{-\frac{1}{n}}$

[The second and third-year students are required to substitute question 12 for question 11.]

Geometry and Mensuration.

1st, 2nd and 3rd years.

1. Explain what do you mean by "method of superposition?" What axiom is made use of in superposition? Name all the propositions in book I which have been proved by this method.

2. Give the definitions of circle, parallel straight lines, diagonals, rhombus, angle in a segment, corollary, and state the three postulates.

3. If a side of any triangle be produced, the exterior angle is equal to the two interior and opposite angles; and the three interior angles of every triangle are together equal to two right angles

4. To inscribe an equilateral and equiangular pentagon in a given circle.

5. Bisect a given triangle by a straight line drawn through a given point in a side.

6 Equal parallelograms which have one angle of the one equal to one angle of the other, have their sides about the equal angles reciprocally proportional. Prove its converse also.

7. The opposite angles of any quadrilateral figure inscribed in a circle are together equal to two right angles.

8. The rectangle contained by the diagonals of a quadrilateral figure inscribed in a circle is equal to both the rectangles contained by its opposite sides.

9. The foot of a ladder placed on a road is at distances of 24 feet and 32 feet respectively from two vertical walls on the opposite sides of the road. It is then successively inclined against the walls in such a manner that the two positions make a right angle Find the length of the ladder.

10. The area of a trapezoid is 8 acres 2 roods 17 poles: the sum of the parallal sides is 297 yards; find the perpendicular distance between them.

11. Find the expense of paving a circular court 30 feet in diameter at 2*s*. 3*d*. per square foot, leaving in the centre a space in the form of a regular hexagon, each side of which is 2 feet.

12. The area of the whole surface of a right circular cone is 32 square feet and the slant height is three times the radius of the base; find the volume of the cone.

13. Find the side widths in a cutting 8 feet deep, side slope 2 to 1, slope of the side long ground 1 in 10, half breadth of the road 20 feet.

14. Find the cost of painting a pontoon with hemispherical ends at 2*s.* 6*d.* a square foot; the length of the pontoon is 20 feet and its diameter is 4 feet.

15. The radius of a sphere is 12 feet; from a point which is at a distance of 15 feet from the centre of the sphere, straight lines are drawn to touch the sphere, thus determining a segment of the sphere; find the area of the curved surface of this segment.

N.B.—The 1st year is to answer 1 to 7 and 9 to 11, both included.
The 2nd and 3rd years are to answer 1, 3 to 6, 8, and 12 to 15, both included.

TRIGONOMETRY.

2nd and 3rd years.

1. State and explain the different modes of measuring angles, and express the angle of an equilateral triangle in each of these systems.

2. What do you mean by the complement and the supplement of an angle? Give the complements and the supplements of the following angles:—

$$135^\circ\ 5'\ 6'',\ 29g\ 75'\ 15'',\ \text{and}\ \frac{2\pi}{3}.$$

3. Prove the following identical relations:—

(1) $\cos x + \sin x \tan x = \sec x.$

(2) $\cot^2 a - \cos^2 a = \cot^2 a \cos^2 a.$

4. Prove geometrically that $\sin(A - B) = \sin A \cos B - \cos A \sin B$.

5. Solve the trigonometrical equations:—

(1) $2 \sin \theta = \tan \theta.$

(2) $\sin \theta - \cos \theta = \sqrt{.2}.$

6. Prove that $\log_a b \times \log_b a = 1$; and solve the equation:— $a^{mx} b^{2x} = c.$

7. In any plane triangle prove that—

(1) $2bc \cos A = b^2 + c^2 - a^2.$

(2) $\text{Sin}\ \frac{A}{2} = \sqrt{\frac{(s-b)(s-c)}{bc}}$

8. Given $b = 609$, $c = 641$, $\log b = 2{\cdot}7846173$, $\log c = 2{\cdot}8068580$, $\log 1250 = 3{\cdot}0969100$, $\log 2 = {\cdot}3010300$.

L cos 18° 10′ = 9·9777938, L cos 18° 11′ = 9·9777523.

Solve the triangle, right-angled at *C*.

9. In any plane triangle, find A from the following data:—

$a = 37$, $b = 13$, $c = 30$, log 9 = ·9542425, log 13 = 1·1139434.

L sin 56° 18′ = 9·9200994, L sin 56° 19′ = 9·9201836.

10. From the top of a hill there are observed two consecutive milestones, on a horizontal road, running from the base. The angles of depression are found to be 45° and 30°; find the height of the hill.

11. A base line of 600 yards was measured in a straight line close to the bank of a river, and at each end of the line the angles were observed between the other end and a tree close to the edge of the river on the opposite side of it, these angles were found to be 52° 14′, and 68° 32′, find the breadth of the river.

Given cot 52° 14′ = ·7747481, and cot 68° 32′ = ·3932386.

N.B.—Questions 1, 2, 3, 4, 5, 6, 7, 8, 10 are for the 2nd-year students; and questions 1, 2, 3, 4, 5, 6, 7, 9, 11 are for the 3rd-year students.

Statics and Hydrostatics.

3rd year.

1. Enunciate the parallelogram of forces.

Forces of 1, 2, 3, 4, 5, 6 lbs. act from the centre of a regular hexagon towards its corners: find their resultant.

2. Find the resultant of two unlike parallel forces.

Six like parallel forces of 1, 2, 3, 4, 5, 6 lbs. are applied to a rigid rod at points one inch apart: find their resultant.

3. Find the centre of gravity of any solid pyramid. $A\ B\ C\ D$ is a rectangle: A is joined to E, the middle point of $C\ D$: find the C. G. of $A\ B\ C\ E$.

4. What are the requisites of a good balance, and show how they are satisfied.

5. In the Danish steelyard if a_n represents the distance of the fulcrum from the end of the steelyard at which the weight is suspended, when the weight is n lbs.; prove that $\frac{1}{a_{n+1}} + \frac{1}{a_{n-1}} = \frac{2}{a_n}$.

6. A right-angled triangle is suspended successively from its acute angles, and when at rest the side opposite the point of suspension in each case makes angles θ, ϕ, with the vertical: shew that $\tan\theta \tan\phi = 4$.

7. Define fluid, fluid pressure, pressure at a point, resultant pressure, whole pressure. Shew that the pressure at a depth $z = g\ \rho z$.

8. Prove that the whole pressure on a surface whose C. G. is at a depth $z = g\ \rho S z$.

A regular hexagon is immersed vertically in a fluid, so that one side coincides with the surface: compare the pressures on the triangles into which it is divided by lines from the centre to the angular points.

9. Define specific gravity.

Two metals of which the specific gravities are 11·22 and 7·25 when mixed in certain proportions without condensation form an alloy whose specific gravity is 8·72: find the proportion by volume of the metals in the alloy.

CHEMISTRY.

2nd year.

1. Describe how you have seen the following substances prepared, and sketch the apparatus:—

(*a*) Oxygen, (*b*) hydrogen, (*c*) nitrogen, (*d*) ammonia, (*e*) hydrochloric acid gas, (*f*) carbon dioxide, (*g*) chlorine, (*h*) sulphur dioxide.

2. How is nitric acid manufactured?

3. Sketch the different parts of a coal gas works, explaining their purpose.

4. Write down the atomic weights of all the non-metals you have studied and the molecular formulas of all their oxides.

5. State the physical properties of phosphorus, sulphur, bromine, sulphuric acid, carbon monoxide.

3rd year.

1. Give an account of the manufacture of pig-iron. Sketch the furnace.

2. Write down the molecular formulas and the molecular weights of the oxides, chlorides, sulphates, and nitrates of potassium, calcium, aluminium, copper, and silver.

3. To what uses are the following substances put in the arts:—chloride of lime, nitrate of silver, sulphate of copper, mercury, zinc, borax.

4. State the physical properties of the different forms of iron, of copper, sodium carbonate, ferrous sulphate, bromine.

5. How are the following substances prepared in the laboratory:—

(*a*) carbon monoxide, (*b*) laughing gas, (*c*) sulphuretted hydrogen, (*d*) calcium chloride, and (*e*) oxygen.

6. State Dalton's atomic theory, and give an account of the facts on which the theory is based.

ESTIMATING.

1. Calculate the quantity of brick-work from the annexed plate.

2. Find out the area for whitewash on the walls only.

10 marks for book-keeping.

SURVEYING.

1st, 2nd and 3rd years.

1. Mention the cases in which a survey by chain only is useful. Explain the principle on which it is based, and the particular points to be observed.

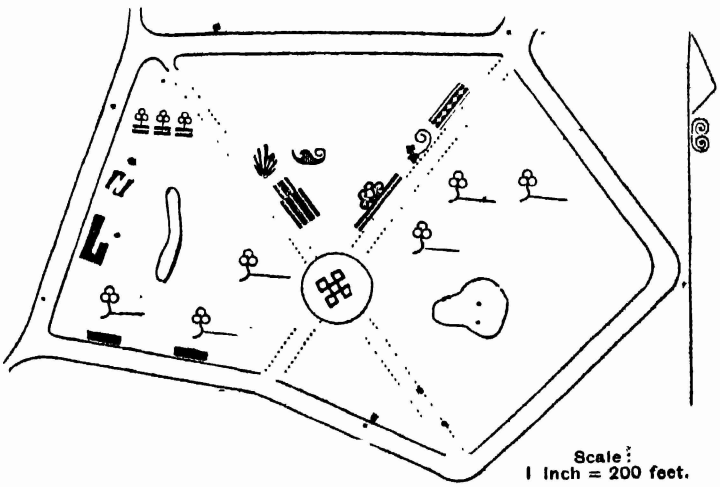
2. A piece of land as measured by a hundred feet chain is one acre. The chain on measuring is found to be 2 inches too long; what is the correct area?

3. Describe the different methods of fixing the position of an object on one side of the chain line.

4. (*a*) Show how to fix an angle by means of a CHAIN only?
(*b*) Lay off a perpendicular with the chain.
(*c*) Find the distance of an inaccessible object without any instruments to measure with.

5. You are to survey a populous city bounded on all sides by roads interlaced by a large number of roads, streets, &c., and with buildings standing along the roadsides. What kind of survey do you prefer? Give reasons for your choice, and describe briefly the main operations of the work.

6. The field in the accompanying sketch is to be surveyed with prismatic compass. Shew the chain lines and off-sets well marked, and make out a field-book complete.



7. Explain the terms—
(*a*) Tie Line, Bearings, Azimuth.
(*b*) Line of Collimation, Virtual Line of Sight, Parallax.

8. (*a*) Name the successive operations of levelling in constructing a road.

(*b*) Describe the temporary adjustments for a Dumpy Level.

(*c*) Reduce the field book in the margin.

9. (*a*) Explain clearly what you understand by the term triangulation.

(*b*) What are the conditions to be fulfilled in a closed traverse?

(*c*) Show how to find the exact station where you stand on the plane table.

Back.	Inter.	Fore	Rise.	Fall.	R. L.	Dist.	Remarks.
4·56					100	0	
	5·34					100	B. M.
6·71		4·21				210	L. B.
	4·30					230	H.F.M.
	4·50					406	H.F.M.
		2·65				430	R. B.

N.B.—First-year is to answer up to 7 (*a*); second-year first 8 questions; third-year the whole paper.

PHYSICS.

3rd year.

1. Give a short description, illustrated by sketches, of different kinds of thermometers. What corrections must be applied to the readings of a common thermometer in order to get the true temperature?

2. Distinguish between apparent and real expansion. Give examples.

Describe how Regnault determined the real expansion of mercury.

3. Enumerate and define the different changes of state which a substance may undergo on application or withdrawal of heat.

4. Describe a simple experiment which shows that the boiling point of water is lowered by lowering the superincumbent pressure, and state generally the circumstances which influence the temperature at which water boils.

5. Give an exact definition of the term conductivity. If one end of two precisely similar pieces of bismuth and iron is covered with wax and the other end placed in a hot vessel, on which metal does the wax begin to melt first; explain.

6. What is meant by convection. In connection with this subject explain the heating of water contained in a vessel placed over fire; and the origin of trade winds, monsoons and land and sea breezes.

7. What are the numerical values of the heat of liquifaction of ice and the heat of vaporization of water at 100° C.

Define specific heat. Discuss the subjects of specific and latent heat with reference to kinetic and potential energy.

8. Describe and illustrate by a sketch how Joule determined the mechanical equivalent of heat. What is meant by the latter term? A quantity of heat H is imparted to a substance (air for instance) working between the temperatures $t_1°$ and $t_2°$ C., how much of that quantity of heat can be theoretically converted into useful work under the given circumstances?

Engineering.

1st, 2nd, and 3rd years.

1. Describe the usual method adopted for quarrying a sedimentary rock, such as sandstone or slate.

2. Describe the method of burning bricks in an ordinary clamp, and state the approximate amount of coal required for half a lakh of bricks.

3. What is kunkur composed of? To what uses is it put, and what ingredient makes it of value as mortar in masonry that has to set under water.

4. Describe the method of applying the stucco known as Madras chunam.

5. Name three specimens of exogenous and endogenous trees of common use in India for constructive purposes, and state the uses each is ordinarily put to.

6. Mention any process you may be acquainted with for the preservation of timber.

7. Describe the process of remelting pig-iron in a cupola so as to render it fit for purposes of casting. Sketch an ordinary cupola with its appliances.

8. State the prismoidal formula for calculating the contents of a cutting or embankment in earthwork. An embankment in the form of a frustum of a regular pyramid is 30 feet high, base is 135 feet by 64 feet, top 75 feet by 4 feet. side slopes 1 to 1; find the volume in cubic feet.

9. What precautions are necessary when new masonry has to be joined to old?

10. In designing the foundations of a building, what calculations are necessary in order to ensure uniform settlement?

11. Sketch the following joints in carpentry:—

(*i*) Junction of queen post with rafter and straining beam.

(*ii*) King post with tie and struts.

N.B.—1st year to answer questions 1—7; 2nd year 1—10; 3rd year whole paper.

DRAWING.

1st year.

1. Print, by hand only, your *name*, date, and the following sentence, in quarter-inch italics:— "Good printing contributes elegance to a bad drawing, but bad printing spoils the appearance of a good drawing."

2. Draw a regular (1) Pentagon, (2) Heptagon, and (3) Octagon, the sides of each figure to be 1 inch, and state the angles of each.

3. Draw the following scales—(1) One-sixteenth full size. (2) One and-a-half inch to a mile, showing furlongs. (3) One and-a-quarter inch diagonal for tenths and hundredths. (4) Scale of chords, and lay of an angle of 35.

4. Draw an ellipse, major and minor diameters, 5 inches and $3\frac{1}{2}$ inches, (2) Draw a perpendicular, and (3) a tangent, to its curve.

5. Construct a square equal in area to a triangle of which the sides are $1\frac{1}{4}$, $2\frac{1}{2}$ and 3 inches.

6. Draw the projections of a square plane of 2-inch side—(1) when the diagonals form angles of 45° to the horizontal and 20° to the vertical planes, and (2) In such a position to both planes, that the "*plan*" and "*elevation*" are exactly alike.

Note.—Pencil only—lines to be clean and distinct.

2nd year.

1. Print, by hand only, your *name*, *date*, and the following sentence, in quarter-inch italics:— "Good printing contributes elegance to a bad drawing, but bad printing spoils the appearance of a good drawing."

2. Draw the following scales—(I) One-sixteenth full size. (II) One and-a-half inch to a mile, show furlongs. (III) One and-a quarter inch diagonal for $\frac{1}{10}$ths and $\frac{1}{100}$ths. (IV) Scale of chords showing its use.

3. Construct a square equal in area to the quadrilateral figure in the accompanying plate.

4. Draw the projections, "on the inclined plane" of a pentagonal prism, width of side $\frac{3}{4}$ of an inch, and length $2\frac{1}{2}$ inches, the axis to be at 40° to the horizontal plane and *plan* of last figure at 30° to the vertical plane.

5. Draw the section, on line AB of heptagonal pyramid in accompanying plate, and develop its surfaces.

6. Give *all* your set squares, compasses, rulers, scales and instruments to the duftry, and *then* ask for, and draw, by freehand only, the copy given to you.

Note.—Pencil only—lines to be clean and distinct.

3rd year.

1. Print, by hand only, *your name*, date, and the following sentence, in quarter-inch italics :—"Good printing contributes elegance to a bad drawing; but bad printing spoils the appearance of a good drawing."

2. Draw the following scales—(I) One-sixteenth full size. (II) One and-a half inch to a mile, show furlongs. (III) One and-a-quarter inch diagonal for $\frac{1}{10}$ ths and $\frac{1}{100}$ ths. (IV) Scale of chords showing its use.

3. Construct a square equal in area to the quadrilateral figure in the accompanying plate.

4. Draw the projections, "on the inclined plane" of a pentagonal prism, width of side $\frac{3}{4}$ of an inch, and length $2\frac{1}{2}$ inches, the axis to be at 40° to the horizontal plane and the *plan* of last figure at 30° to the vertical plane.

5. Draw the section, on line AB of heptagonal pyramid in accompanying plate, and develop its surfaces.

6. Draw a V threaded screw, 2 inches diameter, half-inch pitch, 4 inches long, and section at right angles to the axis.

7. Give *all* your set squares, compasses, rulers, scales, and instruments to the duftry, and then ask for, and draw, by freehand only, the copy given to you.

Note.—Pencil only—lines to be clean and distinct.

APPRENTICE DEPARTMENT.

FINAL EXAMINATION, JULY 1890.

4th year class.

ARITHMETIC AND ALGEBRA.

1. (*a*) Simplify $\frac{3-(\sqrt{2}+1)}{3+(\sqrt{2}-1)} \times \frac{1}{3-2\sqrt{2}}$

(*b*) Express $\frac{5}{8}$ of 2*s*. 3*d* + $\frac{4}{5}$ of a guinea + $\frac{5}{8}$ of £2—$\frac{1}{10}$ of a penny as the fraction of £5.

2. (*a*) Find the value (correct to 6 places of decimals) of—

$$2{\cdot}418 + 1{\cdot}16 + 3{\cdot}009 + {\cdot}7354 + 24{\cdot}042.$$

(*b*) Extract the square root of ·016 and of ·121 to two places of decimals.

3. A gentleman wishes to raise his lawn (which is 1,902 feet long and 1,020 feet broad) 2 feet, and for that purpose digs a moat round it 17 yards broad in every part; supposing the depth of the moat to be uniform, how deep must it be in order that he may have soil sufficient for his purpose.

4. If 15 men, 12 women and 9 boys can complete a piece of work in 50 days; what time would 9 men, 15 women and 18 boys take to do four times as much, the parts done by each in the same time being as the numbers 3, 2 and 1.

5. In what time will £125 double itself at 5 per cent. simple interest.

6. (*a*) Find the L. C. M. of—

$$6\,(a^2-b^2)\,(a-b)^3,\ 9\,(a^4-b^4)\,(a-b)^2 \text{ and } 12\,(a^2-b^2)^3.$$

(*b*) If $2s = a + b + c$. Shew that—

$$(s-a)^2 + (s-b)^2 + (s-c)^2 + s^2 = a^2 + b^2 + c^2.$$

7. Resolve into factors—

(*a*) $x^2 + x - 6$, $x^2 + 2x - 15$, $x^3 - 21x^2 - 13x - 10$.

(*b*) $a^2\,(c-b) + b^2\,(a-c) + c^2\,(b-a)$.

8. Solve the equations—

(1) $(x-a)^3 + (x-b)^3 + (x-c)^3 = 3(x-a)(x-b)(x-c)$.

(2) $ax + by = c$, $mx - ny = d$.

(3) $\frac{1}{x-a} + \frac{1}{x-b} + \frac{1}{x-c} = 0$.

(4) $2^{x+1} + 4^x = 80$.

9. (*a*) The interior angles of a rectilineal figure are in A. P.; the least angle is 120° and common difference is 5.° Required the number of sides.

(*b*) Sum $\frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \frac{1}{16}$ + &c to infinity.

(*c*) The arithmetical mean of two numbers is 3, and the H. M. is $\frac{8}{3}$: find the numbers.

10. Expand $(5 - \frac{x}{6})^6$

(*b*) Find the 3rd term of $(a + b)^{15}$ and middle term of $(a + x)^9$.

Geometry and Mensuration.

1. If a line be divided into two equal and also into two unequal parts, the rectangle contained by the unequal parts, together with the square on the line between the points of section, is equal to the square on half the line.

If a straight line be divided into two parts, the rectangle contained by the segments shall be greatest when the point of division is the middle point of the line.

2. The angles in the same segment of a circle are equal.

The bisectors of the angles standing upon the same arc pass through the same point.

3. Construct an isosceles triangle having each base angle double the vertical angle.

4 If any similar rectilineal figure be similarly described on the three sides of a right-angled triangle, the figure on the hypotenuse is equal to the sum of those described on the two other sides.

5. If a line bisect any angle of a triangle, it divides the opposite side into segments proportional to the adjacent sides.

6. Three gentlemen selected three plots of land of equal area for their gardens—one in the form of an equilateral triangle, the second in the form of a square, and the third in that of a circle: compare the costs of fencing.

7. A 2-feet tube is partly filled with water, a sphere that exactly fits the tube is placed in it, and the water is found to rise just to the highest point of the sphere; how much water was there in the tube?

8. A prism, having a square section, each side of which is 10″, penetrates into a solid cylinder, the diameter of which is 26″; the axes of the two intersect at right angles; find the volume of that part of the prism which is inside the cylinder.

9. How much of the earth's surface can be seen from a height of 10,000 feet? Diameter of the earth = 8,000 miles.

10. Apply Simpson's rule to find the area of the figure having the following ordinates—

2·714, 2·759, 2·802, 2·844, 2·884 feet; common distance 9 inches.

TRIGONOMETRY AND HYDROSTATICS.

1. Define circular measure and express in circular measure an angle of one minute.

2. Find the trigonometrical ratios for an angle of 60°.

3. Prove (1) $\sin C + \sin D = 2 \sin \frac{C+D}{2} \cos \frac{C-D}{2}$

(2) $\frac{\tan(\theta-\phi)+\tan\phi}{1-\tan(\theta-\phi)\tan\phi} = \tan\theta.$

4. Define a logarithm

Given log 2 and log 7, find the 11th root of $(39{\cdot}2)^2$.

5. Prove the formulæ (1) $\cos A = \frac{b^2+c^2-a^2}{2bc}$

(2) $\tan \frac{A}{2} = \sqrt{\frac{(s-b)(s-c)}{s(s-a)}}$

6. Solve the following triangles:—

(1) $A = 53° 24'$, $B = 66° 27'$, $c = 338{\cdot}65$ yards.

(2) $A = 40°$, $b = 131$ $c = 72$.

7. Define a liquid and show how pressure at a point is measured. An area of 20 square feet sustains a uniform atmospheric pressure of 43,200lbs. Find the pressure at any point, taking an inch as the unit of length.

8. Prove the formula $p = g\rho z$.

The pressure at the surface of a liquid is 10lbs. per square inch; that at a depth of 4 feet is 20lbs. per square inch. Find the weight of a cubic foot of the liquid.

9. Find the resultant force which a fluid exerts upon a body totally or partly immersed in it.

Find its value in the following cases when the bodies are totally immersed—

(1) a cube of gold 10 inches edge.

(2) a prism of wood 8·5 × 5·5 × 4·35 inches.

10. Find the condition of equilibrium of a body floating freely. A piece of iron is weighed in air and found to be 25lbs. weight; it is then weighed in water and found to be $21\frac{2}{3}$lbs. Find the specific gravity of iron.

Statics and Dynamics.

1. Enunciate the parallelogram of forces.

Forces of 1, 2, 3, 4, 5 and 6 lbs. act along the sides of a regular hexagon taken in order: find their resultant.

2 Shew that the sum of the moments of two forces meeting at a point is equal to the moment of their resultant.

3. Find the centre of gravity of a uniform triangular lamina.

From the corner of a square piece of cardboard whose side is 6 inches, another square whose side is 2 inches is cut: find the C. G. of the remaining piece.

4. Shew how to graduate the common steelyard.

If the distance of the C. G. of the beam of a common steelyard from the fulcrum is 2 inches, the movable weight 4 oz. and the weight of the beam 2 lbs., find the distance of the zero of graduations from the C. G.

5. Enunciate the laws of limiting friction.

A heavy beam rests with one end on a horizontal pavement and the other in contact with a vertical wall; if the coefficient of friction of the ground and wall be equal to ·3 and the beam is uniform find the inclination of the beam to the horizon when on the point of slipping.

6. Define velocity and acceleration. A train is being pulled up and moves with uniformly decreasing velocity; at a certain time it is going 60 miles on hour, after ·18 seconds its velocity is 80 feet per second; when will it stop?

7. Prove the formula $S = \frac{1}{2}$ ft^2. A train in passing over a quarter of a mile increases its velocity from 5 miles an hour to 35 miles an hour; what is its acceleration?

8. If two particles of masses m and m^1 are connected by a weightless string passing over a smooth pulley; find the acceleration and the tension of the string.

9. Define work and horse-power.

What must be the power of an engine that can keep a train of 100 tons going at the rate of 60 miles an hour on horizontal rails when the friction is equal to a horizontal resistance of $\frac{1}{50}$th the weight of the train.

Engineering and Applied Mechanics.

1. Give a sketch and description of the ordinary coal clamp used in Bengal for brick-burning. What advantage has coal over other kinds of fuel? What is the ordinary size of brick used?

2. What is concrete? If you had to put in a $1\frac{1}{2}$ feet deep foundation course under the walls of a building in Calcutta, of what would you make your concrete, and how would you mix and lay it?

3. What is the difference in composition and properties between pure limes, hydraulic limes and cements?

If you took a freshly-burnt sample of each and mixed water with it, what would be the effect?

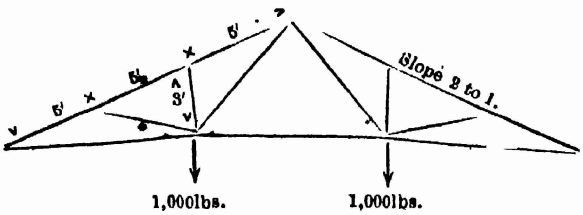
Would any of these three kinds be still fit for use in mortar after a week's immersion in water?

4. Give line drawings of king and queen post trusses, showing compression and tension pieces by thick and thin lines.

5. Sketch the following joints of a wooden king post truss, showing iron straps where necessary (1) principal with tie beam, (2) king post with principals, (3) king post with struts and tie beam, (4) struts with principal rafter.

6. What distinguishes cast-iron, wrought-iron and steel in nature and composition? What are the usual market forms of wrought-iron? Sketch cross sections of cast-iron, rolled, and built girders 18″ deep.

7. Trusses 8 feet apart. Weight of roof covering (including trusses) 20lbs. per sup. foot. Two weights of 1,000lbs. each suspended below. Draw frame and stress diagrams, and find nature and magnitude of stress in each bar. Scales 6 feet = 1 inch and 1,500lbs. = 1 inch.



8. In the last example design the centre horizontal tie (of round iron) and the lower strut (of T iron), the material being wrought iron for which $f_c = 40{,}000$lbs., $f_t = 50{,}000$lbs., $s = 4$, and $c = \frac{1}{3000}$.

9. Find the scantlings of sâl kurries carrying a flat verandah roof, weighing 100lbs. per square foot, placed 1 foot apart centrally and 7 feet span; given $\frac{d}{b} = 2$, $P_b = 800$, $s = 10$.

10. A wrought-iron plate girder of 100 feet span and 8 feet effective depth, carries a uniform steady load of $\frac{1}{3}$ ton per foot run and a uniform moving load of $\frac{1}{4}$ ton per foot run. Design the compression flange at the centre, to be made of plates 12″ wide and $\frac{1}{2}$″ thick and fixed by 2 L-irons 3″ × 3″ × $\frac{1}{2}$″. Also calculate where one plate less may be used. $s_c = 5$ tons.

SURVEYING.

1. A primary scale is divided into inches, tenths, and half-tenths. On the attached vernier 24 of these half-tenths are set off and divided into 25 equal parts. To what degree of accuracy can the vernier be read?

2. Describe how an angle is observed with a theodolite without setting the zero of a vernier to 360.° Describe how an angle is repeated with a theodolite.

3. Complete the accompanying page of levels, and give the arithmetical check.

Back sight.	Intermediate.	Fore sight.	Rise.	Fall.	R. L.	Distance.
7·28	...	...	...	...	5·00	0
...	4·96	...	...	...	...	20
...	5·38	...	...	...	...	45
...	5·97	...	...	...	...	75
4·85	...	6·93	...	...	...	125
...	5 02	...	...	...	...	155
...	6·35	...	...	...	...	205
...	3·27	...	...	...		280
...	3·58	...	...	...	...	380
...	3·76	...	...	...	...	510
...	...	3·50	...	...	...	685

4. Plot the above. Horizontal scale 100′ 1″, vertical 5′ = 1.″ R. L. of 1st point is 5′.

5. How is a surveying chain tested? Describe the two chains ordinarily used, and explain the circumstances under which each would be most suitable.

6. Explain how you can fix your position on a survey by means of (*a*) prismatic compass, (*b*) plane-table and compass.

7. Compare the advantages and disadvantages of the prismatic compass and pocket sextant.

8. Enunciate what is called the "Universal Theorem." How do you apply it to Gale's traverse system, so as to find the area of the polygon?

9. Plot the following:—

Scale 6″ = 1 mile; one bearing is wrong, correct it, giving reasons—

A to B	bearing	45°	distance,	1,320 feet.
B to C	,,	315°	,,	2 furlongs.
C to D	,,	225°	,,	20 chains (Gunter's).
D to A	,,	137°	,,	440 yards.

10. The centre lines of a road meet at an angle of 114° 23′, which angle is to be filled in by a curve of ¼ mile radius; calculate (*a*) length of curve in feet, (*b*) length of tangent in feet, (*c*) angle at circumference for 100′ chord. Natural tangent of 32° 48′ 30″ = ·6446619.

MECHANISM AND STEAM-ENGINE.

1. Define a spur and bevel wheel, and state what is meant by a pitch circle and the pitch of teeth.

2. Explain the action and give a sketch of Whitworth's quick return motion for shaping machines.

3. A sluice gate is to be lifted by means of a vertical screw attached to the gate. The whole resistance caused by the water pressure and the weight of the gate amounts to 6 tons. The pitch of the screw is $\frac{3}{4}$ of an inch. Find what power will be required to be applied at the end of a 6-feet radius of lever, neglecting friction.

4. What is a rack and pinion? Describe its use in a well-known lifting machine.

5. Give a sketch of the double punching and shearing machine.

6. Explain by sketch the difference between undershot and overshot waterwheels and turbines, showing one form of floatboard suitable for each of the first two.

7. Define the unit of work of a steam-engine called a horse-power. Distinguish between nominal and indicated horse-power.

8. If the mean pressure in a cylinder be ascertained from an indicator diagram to be 40lbs. per square inch, what horse-power is being exerted, supposing that the cylinder of the engine is $7\frac{1}{4}$ inches diameter, the stroke is 3 feet, and the number of strokes 2 per second?

9. Explain the principle of a steam-engine governor, and give a sketch showing its connection to the throttle valve.

10. Briefly explain the following terms:—steam jacket, dead points, lap and lead (in valves), superheated steam.

ESTIMATING.

Take out the quantities in the annexed plate.

Rates of Work.

Arch masonry	@ Rs.	30	per	100	cub. ft.
Plain masonry	@ ,,	26	,,	,,	,,
Plastering	@ ,,	3	,,	,,	s. ft.

DRAWING.

1. (*a*) Within a circle of 3 inches diameter construct a regular pentagon.

(*b*) Construct geometrically a square equal in area to a triangle whose sides are 2, $2\frac{1}{2}$, and 3 inches.

2. Draw an elliptic arch formed of 11 voussoirs; span 7 feet, rise $2\frac{1}{4}$ feet, thickness of arch 1 foot. The joints of the voussoirs are to be shewn. Scale 2 feet = 1 inch.

3 Construct:—

(*a*) A diagonal scale of 2 inches to the mile, showing furlongs and tenths of a furlong.

(*b*) A vernier scale (to double size) to read to ·002 of an inch, the primary scale showing ·05 of an inch.

4. Draw a square threaded screw, 3 inches long; pitch $\frac{3}{4}$ inch; thickness and projection of thread, each $\frac{1}{3}$ inch; diameter of cylinder $1\frac{1}{2}$ inches.

5. Draw the projection of a pyramid on a square base, each side of which is 1 inch; height of pyramid 2 inches, and the axis of the pyramid is inclined at an angle of 45° to the horizontal plane, and its plane inclined at an angle of 30° to the intersecting line of the planes of projection.

6. Draw a rough sketch of the cross section, through crown of arch, of a culvert under a road embankment.

[Neatness and accuracy of work will be taken into consideration in awarding marks.]

Chemistry.

1. Describe the properties of oxygen. By what tests can you ascertain its presence? What happens when (1) zinc is heated in air, (2) silver is heated in air?

2. Explain the bleaching action of chlorine; what is the composition of bleaching powder?

3. Describe the decompositions by which sulphuric acid is prepared in the leaden chamber.

4. How much CO_2 can be produced (1) by burning 1lb. of carbon, (2) by burning 1lb. of CO?

5. How is soda carbonate prepared from saltcake? What substance is produced by fusing sajimati (which is a mixture of soda carbonate and clay)?

6. What changes take place (1) when quicklime is mixed with water, (2) when quicklime is exposed to air? How is hard water softened?

7. What chemical changes take place in the manufacture of cast-iron from clay-iron stone?

8. What is the advantage of galvanized iron over tinned iron? How would you distinguish galvanized iron from tinned iron?

9. How much H_2SO_4 is required to neutralize 10 grains of Na_2CO_3?

10. How is lead prepared from galena? What is the action of H_2S upon white lead?

11. How would you prove the presence of CO_2 and Ca in calcium carbonate?

How would you prepare metallic silver from an alloy containing silver and copper?

PHYSICS.

1. Describe how the two fixed points of a thermometer are determined. What corrections must be applied to the readings of a thermometer to get the true temperature?

2. Clearly explain the principle of the gridiron pendulum.

3. Define 'latent heat.' 1lb. of sulphur originally at 30°C is immersed in 5lbs. of melted sulphur originally at 150°C; what is the final result, supposing no heat to be lost by radiation or conduction?

Melting point of sulphur = 111°

Specific heat in the liquid state = 0·234

" " solid " = 0·202

Heat of fusion = 9·4

4. Describe how Joule determined the mechanical equivalent of heat. What was the result obtained?

5 Explain how you would, by means of an electroscope, determine the kind of electricities developed by rubbing a body A with a body B.

6. Describe, and explain the action of, an electrophorus.

7. What happens when a Leyden jar is being charged?

8. State the fundamental laws of magnetism.

9. Describe Daniell's element and explain its action.

10. Describe Oersted's experiment.

11. State Ohm's law. On what does the electric resistance of a given conducting body depend?

APPRENTICE DEPARTMENT.

	Name.	Year.	Present employment.
	Ashini Kumar Mookerjee ...	1883	Public Works Department, Bengal, Railway Branch, Darjeeling.
	A. E. DeSilva	1883	
	W. Traise	1883	Public Works Department, 2nd Calcutta Division.
	W. M. Halloran	1883	Public Works Department. Chittagong Hill Tracts.
5	F. Alone	1883	Overseer, District Board, Benares
	H. Gilbert	1883	Public Works Department, Assam.
	J. R. Moorhouse	1883	Foreman, North-Western Railway Workshops, Lahore.
	E. B. Walker	1883	Calcutta Municipality.
	H. Bryning	1885	Overseer, B. S. Railway, Swebo.
10	C. Perierra	1885	Calcutta Municipality.
	T. Rolston	1885	Public Works Department, Burmah.
	Shoshi Bhusan Ghose	1885	District Board, Chupra.
	Shaik Sudder Ali	1886	Burmah Public Works Department.
	G. Branscombe	1886	Overseer, Arakan Division, Burmah.
15	Bani Kanta Biswas	1886	Furreedpore Municipality.
	Sarat Chundra Roy	1886	Chittagong Public Works Department.
	Jogesh Chunder Bose	1886	Calcutta Public Works Department.
	Rajoni Nath Bál	1886	District Board, Maimansing.
	Basanta Kumar Ghose	1887	Midnapore Technical School.
20	Raghupati Banerjee	1887	District Board, Purneah.
	A. Cuerden	1887	Overseer, North-Western Provinces.
	Harilal Sanyel	1887	Furreedpore District Board.
	O. A. Browne	1887	Public Works Department, Jubbulpur.
	J. C. Damzen	1887	East Indian Railway, Allahabad.
25	W. Gomes	1887	Overseer, Public Works Department, Mandalay.
	Tranoda Churn Mittra	1887	Calcutta Public Works Department.
	J. H. Roy	1887	India General Steam Navigation Company's Steam-ship *Lucknow*.
	Upendra Nath Ganguli	1887	Public Works Department, Calcutta.
	Tumiram Borua	1887	Assam.
30	Bhuban Chundra Banerjee ...	1888	Out of employment.
	Nogendra Nath Chakraverti ...	1888	Public Works Department, Bengal, Railways.
	Jodunath Biswas	1888	Sub-Overseer, Public Works Department, Darjeeling.
	E. Martin	1888	Eastern Bengal State Railway, Lungi, Budge-Budge.

	Name.	Year.	Present employment.
	Heralal Pal	1888	Surveyor-General's Office, Calcutta.
35	Keshub Lal Chatterjee	1888	Kidderpore Dock.
	R. Rogers	1888	Foreman, Lahore Workshop.
	C. Hodge	1888	Midnapore Technical School.
	Batta Krishna Singh	1888	Calcutta Public Works Department.
	Harish Chundra Pal	1888	Jalpiguri Public Works Department.
40	Ashutose Bhattacharjee ...	1888	Chittagong Public Works Department.
	A. E. Linton	1888	East Indian Railway.
	G. Morris	1888	Public Works Department, Cheera Punji.
	A Bonnar	1888	
	Surendronath Mittra	1888	Officiating Teacher, Dacca Survey School.
45	Sarat Chundra Bose	1889	Burn & Co., Howrah.
	P. Westerling	1889	Deceased.
	C. Hottinger	1889	
	Kartick Chunder Bose	1889	Private works, Calcutta.
	H. Michael	1889	Mackintosh, Burn & Co.
50	Degumber Hui	1889	District Board, Mozufferpore.
	Rohini Kumar Bhattacharjee ...	1889	Mozufferpore Railway.
	G. M. Gregory	1889	Penang.
	Jogendra Nath Ganguli... ...	1890	Survey Teacher, Patna College.
	Nripendra Nath Bose	1890	Public Works Department Sub-Overseer, Ranchi.
55	Srimanta Ch. Chowdry	1890	
	Brojendra Kumar Dass	1890	Overseer, Karremgunge.
	D. W. D'Cruze	1890	
	C. J. Homer	1890	
	G. F. Hottinger	1890	Calcutta Municipality.
60	J. S. O'Connell	1890	Overseer, Central Provinces.
	Sreekanta Roy	1890	Ditto, Local Board, Perozepore, Barisal.
	Romesh Chunder Dutt	1890	Head Master, Technical Institution, Barisal.
	Modhu Sudan Adhicary ...	1890	Unemployed.
	Surjee Kumar Chatterjee ...	1890	
65	Rojoni Kanta Deb	1890	Kashipore Municipality Surveyor.
	Upendra Nath Hazra	1891	
	Panch Cowri Mukerjee	1891	
	Satis Chundra Mittra	1891	
	J. G. Dolmar	1891	
70	Gyanendra Nath Banerjee ...	1891	Private Workshop, Seebpore.
	Kristo Dhone Ghose	1891	Overseer, Public Works Department, Arrah.
	R. D. Clark	1891	
	Haran Chunder Biswas	1891	
	Hari Narayan Sarkar	1891	
75	Chandra Kanta Chatterjee ...	1891	

N.B.—Any accuracies in above list should be brought to the notice of the Principal. Passed apprentices out of employ should register their names and addresses in the Principal's office. It is particularly requested that, on any apprentice getting and appointment or changing his appointment, the information be forwarded to the Principal for incorporation in the College Calendar.

MISCELLANEOUS CERTIFICATE HOLDERS.

Certificates granted under Section I, paragraph 13, *Chapter II, Public Works Code of* 1878.

ASSISTANT ENGINEERS.

Name.	Year.	Remarks.
Lalit Mohan Basack	1881	Also passed L. C. E.
T. B. Byers	1881	Ditto.
P. W. Byers	1881	Ditto.
Kapeleswar Bhattacharjee ...	1881.	
Sita Prosono Ray	1882	Also passed L. C. E.
Mrityunjoy Bhattacharjee ...	1882	

Certificates granted under Section II, paragraph 51, *Chapter II, Public Works Code of* 1878.

SUB-ENGINEER.

Ram Das Bhattacharjee ...	1884	

Certificates granted under Section II, paragraph 31, *Chapter II, Public Works Code of* 1878.

OVERSEERS

Amir Uddin	1880	
Abinas Chunder Roy	1880	Also passed L. C. E.
Kapileswar Bhattacharjee ...	1880	Passed for Assistant Engineer.
Nemai Churn Ghose	1880	
Gopal Chunder Bhattacharjee ...	1880	
Russick Lal Mukerjee	1880	
Lolit Mohun Basak	1880	Passed L. C. E.
Pran Krishna Sen	1880	Ditto.
Sita Prosonno Roy	1880	Ditto.
Bishnuram Chakraverti ...	1880	
Satya Churn Banerjee	1881	Passed L. C. E.
Kali Krishna Mozoomdar ...	1881	
Apurva Krishna Sen	1881	
Kali Gopal Rudra	1881	
C. E. Lefeuvre	1882	
Annoda Prosad Pal	1882	
Shama Churn Ganguli	1882	
Akhil Chunder Marik	1883	Passed L. C. E.
Lal Chand Mittra	1883	
Banku Behary Mukerjee ...	...	Passed L. C. E.

Certificates granted under Section I, paragraph 8, *Chapter II, Public Works Code of* 1870.

SUB-OVERSEERS.

Name.	Year.	Remarks.
Sudhamay Dutt	1880	
Monmotho Nath Mukerjee ...	1880	
Haripodo Chatterjee	1880	
Sivadas Bhattacharjee	1881	
Lal Chand Mittra	1881	Also passed as Overseer.
Sarat Chunder Roy	...	
Annoda Prosád Sarkar	1881	Passed L. C. E.
Tarini Churn Roy	1881	
Mohim Chundra Rudra ...	1882	
Banwari Lal Banerjee	1883	
Chandra Kanta Bose	1890	

Certificates granted under Director of Public Instruction's No. 5677, *dated* 23*rd July* 1884.

THIRD GRADE OVERSEERS.

Kuloda Nandan Mukerjee ...	1885	
Preo Nath Roy	1886	
Jadu Nath Mittra	1886	
Surendra Nath Sen	1886	
Troylocko Nath Dutt	1888	
Gopal Chundra Roy	1888	
Nebaran Chundra Chatterjee ...	1888	
Surja Kumar Dass	1889	
Makhan Lal Sarkar	1890	
Chanchal Chundra Banerjee ...	1890	
Jogendra Lal Pal	1890	
Notobar Ghosal	1891	
Kaliprosonno Sen	1891	

Certificates granted under Director of Public Instruction's No. 4221, *dated* 15*th May* 1884.

SUB-OVERSEERS.

Raj Kumar Ganguli	1884	
Jadub Chunder Chatterjee ...	1885	
Bepin Behari Gupta	1885	
Sitanath Bhuttacharjee	1885	
Nikunja Behary Bose	1886	
Bejoy Krishna Mukerjee ...	1886	

Certificates granted under Director of Public Instruction's No. 4221, *dated* 15*th. May* 1884—contd.

SUB-OVERSEERS—*contd.*

Name.	Year.	Remarks.
Nritya Gopal Bhuttacharjee ...	1886	
Raj Krishna Mandal	1887	
Heera Lal Santra	1887	
Chanchal Chundra Banerjee ...	1887	Also passed as 3rd grade Overseer.
Kaliprosonno Sen	1887	Ditto ditto.
Baroda Kanta Thakoor	1888	
Sidheswar Mozoomdar	1888	
Gopal Chundra Lahiri	1888	
Upendra Nath Sen Gupta ...	1888	
Mohendra Nath Gossamy ...	1888	
Kamini Kanta Bhuttacharjee ...	1888	
Upendra Nath Chandra ...	1888	
Annoda Churn Ghose	1888	
Protap Chunder Ghose	1889	
Dakshinaranjan Muchaddi ...	1889	
Taraknath Chowdry	1891	
Soshibhusan Bhuttacharjee ...	1891	
Pulin Behary Ghose	1891	
Jaggut Bundhoo Gupta... ...	1891	
Brojendra Nath Chatterjee ...	1891	
Saroda Prosad De	1891	
Surendra Nath Banerjee ...	1891	
Ashutose Chatterjee	1891	
Nogendranath Chatterjee ...	1891	
Lalbehary Roy	1891	
Brindaban Chunder Mukerjee ...	1891	
Pulin Behary Shaha	1891	

ACCOUNTS.

Examination qualifying for admission to the Subordinate Accounts Branch for 4th Grade, P. W. D.

SUBJECTS FOR EXAMINATION.

	Full marks.	Minimum pass marks.
Writing (neatness, clearness and rapidity) ...	100	50
Dictation (spelling, punctuation, &c.) ...	100	50
Arithmetic (whole course)	240	160
Mensuration (a) (whole book)	60	30
Book-keeping (b) (Mercantile)	100	50
Total	600	400
		Minimum required in all papers collectively.

(a) Todhunter's Mensuration for beginners.
(b) "Book-keeping" by Ball and Hamilton.
"Book-keeping" by double and single entry, by W. Inglis (Chamber's Educational Course).

The marks gained by candidates who fail will not be published.

1. The examination is held annually at the Civil Engineering College, Seebpore, on the 1st Monday in June. The examination will be conducted either at the College or by an Examiner, Public Works Accounts (including Railway and Telegraph) in Bengal, Assâm, and Burmah only.

Candidates will not be examined in any of the Calcutta offices.

2. Candidates not in Government employ who wish to be examined at the College must forward their applications direct to the Principal; those employed in Government offices through the head of their office, who will forward the application to the Principal.

All applications must reach the Principal 30 days before the date of examination.

3. The candidate should apply to an Examiner of Public Works Accounts not later than 30 days previous to the date fixed for the examination, and obtain his consent to conduct the examination if examination at the College is not convenient The application must be forwarded by the candidate, not direct to the Principal, but through the Examiner.

4. All applications must be accompanied by fee of Rs. 10 and the following certificates.

Certificates may be submitted in original, or true copies attested by an officer of the Engineer or Accounts Branch, but none will be returned:—

(1.) Certificate of good character signed by applicant's immediate official superior, or by the instructor under whom he has been educated, or by some other superior under whom he may have been brought up or employed, or to

whom he may be well known. (This certificate must have special reference to the two years immediately preceding the application.)

(2.) Certificate that candidate is under 25 years of age (not required if candidate is in permanent Government employ, or an employé, under District Boards).

(3.) Certificate that the application is in candidate's handwriting.

It will rest with the Principal of the College, on a consideration of these certificates, to decide whether the candidate should be registered for the examination, or whether his application should be rejected.

5. Copies of examination papers are not procurable except those that are issued for examination. These need not be returned.

6. Each examination is complete in itself. A candidate who has failed in an examination, and presents himself for examination on a subsequent occasion, must undergo the full examination, and furnish a fresh fee and certificates.

7. Passed candidates should apply, not to the Principal of the College, nor to the Accountant-General, Public Works Department, but direct to the Examiner of Public Works Accounts in the Province or Railway under whom they may desire to be employed.

8. It must be distinctly understood that the passing of this examination does not give any claim to an appointment, and that in making appointments, preference will be given to qualified persons who are already employed in the Department.

ACCOUNTANTS.

	Names.	Year.	
	4th grade Accountants.		
	Sarada Prosad Bhattacharjee ...	1880	Passed under section IV, paragraphs 59 and 60, Chapter II, P. W. D. Code of 1878.
	Lalla Nanak Chand ...	1880	
	Shangsor Chander Banerjee ...	1880	
	Gustadji Dhanjishah Kagsadia	1880	
5.	Albert Clifford Owen ...	1880	
	Sarabjee Bamanjee ...	1880	
	Abhoy Charan Roy ...	1880	
	Choony Lall Magan Lall ...	1880	
	Ram Chander Bhote ...	1880	
10.	James D. Rozario	1880	
	T. McCann	1880	
	Uma Prosad Bagchi ...	1880	
	Amrito Lall Bose	1880	
	Notobor Mukerjee ...	1880	
15.	Nondo Lall Bhattacharjee ...	1881	
	Sidheswar Roy	1881	
	W. J. Dunn	1881	
	Mohendro Nath Roy ...	1881	
	Dwarka Nauth Sen ...	1881	
20.	Kedar Nauth Biswas ...	1881	
	David O'Dowda	1881	
	George Augustus Damzen ...	1881	
	Aghore Nauth Dutt ...	1881	
	Nobin Krisna Bhattacharjee ...	1881	
25.	Uma Sankar	1881	
	J. Corrigan	1881	
	Kamikhya Nauth Banerjee ...	1881	
	Moolji Bhagwan Shett ...	1881	
	A. C. C. McLeish	1881	
30.	Baidya Nauth Bhattacharjee ...	1881	
	Jogot Chander Mukerjee ...	1881	
	A. Ganguly	1881	
	William Kelly	1881	
	Gour Gopal Dey	1881	
35.	Ranga Nauth Kasi Nauth Fausi	1881	
	Kirti Chander Chatterjee ...	1881	
	Ganoda Prosad Ganguly ...	1881	
	Francis George Harris ...	1881	
	Jules Bell	1881	
40.	Atul Krisna Dutt	1881	
	Behary Lal Chatterjee ...	1881	
	T. Subramoney Aun ...	1881	
	Arthur McLean	1881	
	Keshub Chander Singhi ...	1881	
45.	Dasorothi Banerjee... ...	1881	
	Lalla Mulk Roy	1882	
	Amor Nauth Ganguly ...	1882	
	J. W McGrath	1882	
	Richard Frederick Drame ...	1882	
50.	Lalla Nibu Ram	1882	

	Names.	Year.	
	4TH GRADE ACCOUNTANTS—*continued.*		
	Pundit Gopi Nauth ...	1882	Passed under section IV, paragraphs 59 and 60, Chapter II, W. P. D. Code of 1878.
	Sree Nauth Mittra ...	1882	
	Keshob Chander Ghose ...	1882	
	C. Narsiah ...	1882	
55.	P. Varejanabhudu Naidu ...	1882	
	Cheddi Lal	1882	
	Bhowani Charan Boral ...	1882	
	Shashi Bhusan Pal ...	1882	
	William Lemon	1882	
60.	E. L. Richards	1882	
	Daniel Bates	1882	
	Upendro Nauth Mittra ...	1882	
	Narayan Chander Roy ...	1882	
	John Green	1882	
65.	W. H. E Turner	1882	
	Sarat Chander Mitter ...	1882	
	Nezaiudin	1882	
	Autul Behary Dass ...	1882	
	Mohini Mohon Bhattacharjee...	1882	
70.	Oscar William Malletti ...	1882	
	Rajendro Nauth Mukerjee ...	1882	
	Alexander M. Carson ...	1882	
	John Thobwing	1882	
	Alice Alex. Philbert ...	1882	
75.	Sam Joachim	1882	
	Cecil Joachim	1882	
	Vallah Hargovindo Almarram Bhuckhanwalla	1882	
	Shoshi Bhusan Pal ...	1882	
	Nicholas John Jebb ...	1882	
80.	Makhan Lal Roy	1882	
	Bireswar Mukerjee ...	1882	
	John Rodda Dunn... ...	1882	
	Herbert Butterfield ...	1882	
	Probodh Chander Gupta ...	1882	
85.	Madho Ram	1882	
	Archibald Gregory ...	1882	
	Thomas Michell Shaw ...	1882	
	James Argyle Smith ...	1882	
	Reginald Peyton Dunlop Burbridge	1883	
90.	Tranada Charan Mittra ...	1883	
	Augustus DeSouza ...	1883	
	Reginald Medlycott ...	1883	
	Nathu Jamnadas	1883	
	Sarat Chander Chowdhury ...	1883	
95.	Nobin Chander Sen ...	1883	
	Annada Prosad Dutt ...	1883	
	Richard A. Creenumey ...	1883	
	Mahomed Jalaluddin ...	1883	
	Bhogobote Charan Mukerjee ...	1883	
100.	Alexander Fernie	1883	
	Pundit Modon Mohon ...	1883	
	Abdul Goni	1883	

	Names.	Year.	
	4TH GRADE ACCOUNTANTS—*continued.*		
	Shoshi Kumar Mozoomdar ...	1883	Passed under section IV, paragraphs 59 and 60, Chapter II, P. W. D. Code of 1878.
	Kedar Nath De	1883	
105.	Hari Nauth Singha ...	1883	
	Thakur Das	1883	
	Le. C. Rostan	1883.	
	Kailaspotty Banerjee ...	1883	
	Moti Lal Mukerjee ...	1883	
110.	Debi Singh	1883	
	Adhor Nauth Banerjee ...	1883	
	Hira Lal Roy Chowdhury ...	1883	
	James Thomas Evans ...	1883	
	J. Geo. B. Armour... ...	1883	
115.	E. L. Mendes	1883	
	Damodor Dutt	1883	
	Karam Chand	1883	
	Earnest H. D'Cruz ...	1883	
	Govindo Ram	1883	
120.	Ram Chander Chaturwedi ...	1883	
	Chirag Deen	1883	
	Tarapodo Ghose	1883	
	James Younan	1883	
	Chatturbhooj Dobey ...	1883	
125.	Parjaram Naratam Das Adhyaree	1883	
	Hari Charan Dutt ...	1883	
	Ram Chander Banerjee ...	1883	
	Pundit Niranjan Nauth ...	1883	
	Mul Raj Khoola	1883	
130.	Pundit Ishar Das	1883	
	Bapalal Kikabhai... ...	1883	
	Moola Ram	1883	
	Kirtibas Bhattacharjee ...	1883	
	Jogesh Chander Chatterjee ...	1883	
135.	Louis R. St. Romaine ...	1883	
	Makando Ram	1883	
	Mohon Lal	1883	
	Monohor Lal	1883	
	Hem Chander Ghose ...	1883	
140.	A. Belletty	1883	
	Sham Narayan	1883	
	Jamsetjee Eduljee ...	1883	
	Ishar Das	1883	
	Gunda Singh Moonshi ...	1883	
145.	Tulsi Ram	1883	
	Charles Raymond Martin ...	1883	
	Okhoy Kumar Roy ...	1883	
	Ganga Shohay	1883	
	R. Krishna Sawmey Naicker ...	1883	
150.	Sohan Lall	1884	
	Nripendro Nath Roy ...	1884	
	Jerome Andrew	1884	
	R. Dowling	1884	
	Ram Narain Banerjee ...	1884	
155.	Karim Baksh	1884	

	Names.	Year.	
	4TH GRADE ACCOUNTANTS—*continued.*		
	Charles Lodrick	1884	Passed under section IV, paragraphs 59 and 60, Chapter II, P. W. D. Code of 1878.
	Ahmed Din	1884	
	Edmond D'Rozario ...	1884	
	Troylukhyo Nath De ...	1884	
160.	Novin Chander Bhattacharjee	1884	
	Durga Prosuda	1884	
	Deepa Shah	1884	
	H. C. V. Sage	1884	
	Henry Walter Fegudo ...	1884	
165.	C. Muirhead	1884	
	Ananto Ram	1884	
	C. S. Murphy	1884	
	Mahomed Abdoollah ...	1884	
	Tarapodo Ghose	1884	
170.	Balkrisna Trinbock ...	1884	
	Dabendro Nauth Roy ...	1884	
	Ganga Ram	1884	
	Kasim Beg	1884	
	Barkat Alli	1884	
175.	Mohendro Nauth Ghose ...	1884	
	W. W. De Lattoyde ...	1884	
	Debi Doyal	1884	
	C. L. Jose	1884	
	Gowri Ditta	1884	
180.	Barada Kanta Chowdhury ...	1884	
	Khetra Mohon Bose ...	1884	
	Troylukyo Nauth Chakerbutty	1884	Passed under section IV, paragraphs 59 and 60, P. W. D. Code, 1878.
	Hakim Din	1884	
	V. E. Nepos	1884	
185.	Frederic Chaplin Nisbet ..	1884	
	Badhwa Mul	1884	
	Hera Nand	1884	
	Shyam Lal	1884	
	Kannyhia Lall	1884	
190.	Lakhpot Roy	1884	
	Bipin Behary Dey... ...	1884	
	T. Narain Swamey Pillay ...	1884	
	Madho Lall	1884	
	Edmund Cannon Maylan ...	1885	
195.	Arthur Henry Hammill ...	1885	
	Dinshaw Manickji... ...	1885	
	Ram Lal Roy	1885	
	Jugal Kisore Byasack ...	1885	
	Ram Chander Govind Talvalkar	1885	
200.	Gopal Das	1885	
	Chandra Mohon Das ...	1885	
	Dharma Das Mukerjee ...	1885	
	Herambo Nauth Chatterjee ...	1885	
	Butto Behary Dhor ...	1885	
205.	Brojo Lal Sanyel	1885	
	Bama Charan Chakerbutty ..	1885	
	Amor Nauth Pundit ...	1885	
	Makhan Lal Ghose ...	1885	

	Names.	Year.	
	4th grade Accountants—*continued.*		
	Bhola Nauth	1885	Passed under section IV, paragraphs 59 and 60, P. W. D. Code, 1878
210.	Bipin Behary Batavyal ...	1885	
	Rajendro Nauth Banerjee ...	1885	
	Denis O'Hearn	1886	
	G. H. Coleman	1886	
	Poorna Chander Dey ...	1886	Passed under section IV, paragraphs 59 and 60, Chapter II, P. W. D. Code, 1878.
215.	Nil Prosonna Ghose ...	1886	
	Kiran Chander Banerjee ...	1886	
	Rash Behary Addi ...	1886	
	Gerald Leith Godwin ...	1886	
	Bipin Behary Banerjee ...	1886	
220.	Poorna Chander Chatterjee ...	1886	
	R. J. Morton	1886	
	Robert Walsh	1886	
	Bidhu Bhusan Banerjee ...	1886	
	Radha Kanto Roy... ...	1886	
225.	Munshi Willoyut Hossain Khan	1886	
	Debendro Nauth Bose ...	1886	
	Ashutose Neogy	1886	
	Robert F. George ...	1887	Passed under Appendix C, paragraphs 12 and 18 of P. W. D. Code of 1886.
	Jiban Krisna Chander ...	1887	
230.	Hyginus Domerric ...	1887	
	Gracias	1887	
	Bipin Behary Chandra ...	1887	
	Nil Kanto Chatterjee ...	1887	
	Girish Chander Gupta ...	1887	
235.	Dennis O'Sullivan ..	1887	
	Moti Lall Sen	1887	
	A. D. Rozario	1887	
	Michael Charles Edward Dorris	1887	
	Akhoy Kumar Banerjee ...	1887	
240.	Arthur Joseph George ...	1887	
	A. Rainford	1887	
	Leonard Colthurst ...	1887	
	John S. Riley	1887	
	Haraprosad	1887	
245.	Edward Bertram James ...	1887	
	Radha Charan Banerjee ...	1887	
	Kaliprosonna Banerjee ...	1887	
	Kunjabehary Lal	1887	
	Mohendro Nauth Das ...	1887	
250.	Shoshi Bhusan Dutt ...	1887	
	Bacharam Audhicary ...	1887	
	Beniprosad	1887	
	Kallidas Bose	1887	
	Uma Nauth Singh ...	1888	
255.	James William Fillinger ..	1888	
	James H. Cameron ...	1888	
	Ashutosh Bhattacherjee ...	1888	
	William O'Cesar	1888	
	E. W. Hall	1888	
260.	George Hamilton	1888	

	Names.	Year.	
	4TH GRADE ACCOUNTANTS—*concluded.*		
	Shushil Kumar Bose ...	1888	Passed under Appendix C, paragraphs 12 and 18, P. W. D. Code of 1886..
	Jogendro Kumar Bhadra ...	1888	
	Walter Harold Hodges ...	1888	
	Mihir Chander Dutt ...	1888	
265.	W. A. Samuel	1888	
	Ashutosh Mookerjee. ...	1888	
	A. Cum Sone	1888	
	Abinash Chander Ghosh ..	1888	
	A. Vaughan	1889	
270.	Robert Cresswell Keating ..	1889	
	Nilmoney Bose	1889	
	G. Whyte	1889	
	T. A. Johnson ...	1889	
	Nirode Chander Mozomder ...	1889	
275.	Hemadrish Chander Bhattacharjee	1889	
	Bhabani Charan	1889	
	E. Jewell	1889	
	A. Ben Court	1889	
	Albert Aukim	1890	
280.	Kalipodo Banerjee ...	1890	
	Behary Lall Koleh ...	1890	
	Brij Behary Sett	1890	
	Bipin Behary Dutt ...	1890	
	Ujjal Chander Sen ...	1890	
285.	Bata Krisna Ghose ...	1890	
	Nogendro Nauth Mittra ...	1890	
	Robert B. Smart	1890	
	Arnold Roberts	1890	
	Stephen Robert Ewing ...	1890	
290.	Gourdas Roy	1890	

CIVIL ENGINEERING COLLEGE, SEEBPORE.

ANNUAL REPORT, 1889-90.

ENGINEER DEPARTMENT.

Class.	Hindus.	Europeans and Eurasians.	Mahomedans.	Burmese.	Native Christians.	Total.
1st year	20	2	...	1	1	24
2nd "	15	2	...	1	...	18
3rd "	11	1	1	1	...	14
4th "	8	2	...	...	...	10
Total ...	54	7	1	3	1	66

The above table shows the constitution of the Engineer Department on the 1st April 1889.

B.E. and L.E. Examinations.

The Calcutta University Examination for B.E. and L.E. commenced on 1st July. The ten 4th-year students, plus three previous failures, presented themselves before the Examiners. Of these thirteen candidates, nine, or 69 per cent. were successful, one of them, W. S. Bremner, L.E., passing in the 1st division, he as 1st on the list gains the one guaranteed appointment for the present year; whilst the Ambica Charan Chawdhuri gold medal for the B.E. who scores highest in mathematics falls to Sotish Chandra Chatterjee, B.E.

Eight of these young men are now undergoing their 12 months' practical training with the Public Works Department. Two of them were nominated by the Principal for the examination for the post of Assistant Surveyor, 3rd grade, held by the Surveyor-General, and both were successful, but only one joined the Survey Department, the other preferring to undergo one year's practical training.

F. E. Examination.

The F.E. Examination was held on the 6th May and ten following days.

The fourteen 3rd-year students, plus two who failed in the previous year, appeared at this examination, and fifteen, or 93 per cent., passed, all in the 2nd division. The one who failed did so in the aggregate only.

College students may be said to have been very fairly successful at the University Examinations during the year under review.

The present 4th-year class consists of sixteen students, viz.:—Fourteen who passed the above F.E. Examination, plus two who failed for L.E. or B.E., one successful F.E. left College, preferring to take up a subordinate appointment offered to him.

Annual examinations.

The college annual examinations were held during May, those in shopwork commencing on the 13th, and in class work on the 27th.

Ten out of the eighteen 2nd-year students, or 55·5 per cent, were promoted to the 3rd-year class. It is satisfactory that none failed in shops.

Fourteen out of the twenty-four 1st-year students, or 58 3 per cent., gained promotion to the 2nd-year class. Seven failed in class-work, one in shop-work, and two in both practice and theory. Eight previous failures rejoined, one retired during the year; thus the 2nd-year class now consists of 21 students.

The results of these two College examinations appear to prove conclusively that, under the present system, boys are admitted to the Department, who have no chance of getting through the course, consequently the Director of Public Instruction has been requested to sanction the raising of the Entrance standard in accordance with the recommendations of the Seebpore College Enquiry Committee.

Admission.

Ninety-seven lads, who had passed the University Entrance Examination, applied for admission into the Engineer Department in June, but only forty-eight did actually join, and of these fourteen left College during the year for various reasons. Six, who failed to gain promotion to the 2nd-year class, rejoined; thus there are now 40 students in the 1st year class.

The table below shows the state of the Engineer Department on the 31st March 1890.

Class.	Hindus.	Europeans and Eurasians.	Mahomedans.	Burmese.	Total.
1st year	34	4	1	1	40
2nd "	20	...	...	1	21
3rd "	8	2	.	...	10
4th " ...	13	1	1	1	16
Total ...	75	7	2	3	87

The total on the 31st March 1889 was 66.

APPRENTICE DEPARTMENT.

Class.	Hindus.	Europeans and Eurasians.	Mahomedans.	Total.
1st year	37	5	...	42
2nd "	38	3	..	41
3rd "	17	1	1	19
4th "	9	3	...	12
Senior	10	4	...	14
Total ...	111	16	1	128

The above table gives the numerical strength of the Apprentice Department on the 1st April 1889.

Of the 14 senior apprentices, *i.e.*, those who have passed their final examination and are employed altogether in the shops, ten left college on the 31st January with the usual Foreman-Mechanic or Upper Subordinate certificates, the other four are remaining till June next in order to complete their full term of apprenticeship, as they joined in that month five years ago.

Final examination.

The final examination of the 4th-year class took place in July last; 12 boys, plus one previous failure, were examined, and all were successful; one left, with an appointment, therefore there are now 16 senior apprentices including the four who, as above stated, remain till June.

Annual examinations.

The annual examinations were held in January. Sixteen 3rd-year apprentices were examined (one previously left with an appointment, one withdrew his name, one was degraded for failing to pass a supplemental examination), all passed, and one previous failure rejoined, thus making 17 in the 4th-year class at the end of the year.

The 2nd-year class consisted of 41 boys plus one degraded from 3rd year. Of these 42, two died at their homes when on sick leave, one was ill, so that 39 were examined, 4 failed in class work only, thus there are 35 in the 3rd-year class.

Seven boys who passed the University Entrance Examination joined the 1st year class in June last; five retired during the year, consequently 44 appeared for examination, 2 failed in shops, 9 in class-work and 1 in both, leaving 32 successful; 3 boys rejoined, therefore there are 35 in the 2nd-year class.

Admission.

For the admission examination in January 163 names were registered, and 129 lads presented themselves for examination. Of these 57 passed and 52 joined the Department. In addition, one who passed the University Entrance Examination, 3 who passed the same in English and mathematics, and 8 Europeans who passed by standard VII, were admitted. Ten boys rejoined, and 3 of the new admissions withdrew, thus making 71 in the 1st-year class at the end of the year. This class is quite as large as the teaching staff can cope with, and the barracks are now full; consequently it will be necessary to refuse those seeking admission in June under the provisions of the last part of rule 7.

The table underneath gives the state of this Department on the 31st March 1890:—

Class.	Hindus.	Europeans and Eurasians.	Mahomedans.	Total.
1st year	59	11	1	71
2nd "	34	1	...	35
3rd "	33	2	...	35
4th "	15	1	1	17
Senior	13	3	...	16
Total ..	154	18	2	174

against a total of 128 on the 31st March 1889. In addition there are four artizan pupils from Assam, who are instructed altogether in the workshops, consequently the grand total on the College books at the close of the year was 265, and all these, with the exception of 9, reside upon the College premises.

Grand total.

The 40 reduced-feeships granted by Government to natives are all taken up, but amongst the 25 for Europeans there are 18 vacancies. Five Europeans are admitted free; this list is full.

An examination for admission to the 4th grade of Accountants, Public Works Department, was held on the 1st Monday in June and following day. Fifty-two candidates registered their names, all of these presented themselves for examination, 10 passed and received the usual certificates.

Accountants.

In accordance with rules 10 and 11 of the Apprentice Department 1 Overseer's and 2 Sub-overseer's certificates were granted by the Principal to boys leaving College before the completion of their apprenticeships, these 3, plus the 10 final certificates already referred to, make a total of 13 subordinate engineering certificates issued by the College during the year.

Certificates.

Mr. J. S Slater, Professor of Engineering, proceeded to England on six months' furlough on 20th February, and Mr. F. O. Oertel, Assistant Engineer, Public Works Department, whose services have been lent by the North-Western Provinces Government, is acting for him. Baboo Baroda Prosad Ghose, M.A., Lecturer in Physical Science, Apprentice Department, went on privilege leave for three months from 5th December, and Baboo Jyoti Prosad Chatterjee, M A., acted for him.

Changes in staff.

At the close of last year Baboo Dwarka Nath Datt, Teacher, Apprentice Department, was on sick leave, with Baboo Satish Chander Chatterjee acting for him; this arrangement continued till 8th April, when Baboo Radharomone Guho, L.C.E., took the latter's place, and remained until the return of Baboo Dwarka Nath Datt on 11th November. Baboo Surendro Kumar Bose, B.C.E., Teacher, Apprentice Department, took one year's leave without pay from 13th May, and Baboo Hari Charan Mookerji, L.E., has acted for him since the 16th of that month.

A qualified European Head Master for the Apprentice Department is, as was pointed out in last year's report, much needed.

No buildings were erected during the year. The schemes for a model-room and hospital buildings, urgently required, remain in abeyance. As a temporary measure the upper floor of the eastern wing in the central block of the Hindu students' quarters was set apart as a hospital in June last. This is an unsatisfactory arrangement, and it absorbs accommodation for some 20 students.

Buildings.

The public road along the foreshore has not been completed.

Survey work with the 2nd and 3rd year engineer classes commenced in November, in the vicinity of Madhupur station, East Indian Railway, and continued till the end of January. The 3rd-year students were in camp from 19th November till 13th January. This class laid out a line of railway

Field work.

about 5½ miles in length. Having selected the line, its position was laid down by the theodolite, and the curves set out; it was then levelled over, cross sections were taken, and the details of the country passed through were filled in by planetable. The 2nd-year students came into Camp on 26th November and remained till 30th January; they were engaged upon an extensive Trigonometrical and Traverse Survey, the details of which were filled in by planetable, also some time was occupied in levelling, contouring, laying out curves and side widths, and in erecting profiles for embankments on sloping ground. In addition some astronomical observations were made. The 1st-year Engineer class executed a chain and compass survey of the Botanical Gardens, and were taught levelling and ground-tracing.

The 1st, 2nd and 3rd year Apprentice classes were instructed in chain, compass and theodolite surveying and in levelling, in the neighbourhood of the College.

Works visited.

Mr. Slater, Professor of Engineering, during the cold season visited the undermentioned works with the senior Engineer-students:—

(1) Pottery Works, Raneegunge.
(2) Cement Works, Raneegunge.
(3) Damuda Bridge, Bengal-Nagpore Railway.
(4) Barrakur Iron Works.
(5) Jamalpore Workshops.
(6) Steam-ship *Sir Bradford Leslie.*
(7) Kidderpore Docks.
(8) Burn and Company's Workshops, Howrah.
(9) East Indian Railway Carriage Department, Howrah.
(10) Chitpore Lock
(11) Barrackpore Road Bridge.
(12) Calcutta Waterworks, Pulta.
(13) Hughli Floating Bridge.

Visitors.

The Board of Visitors met once during the year, and transacted the business brought before it. Sir Alfred Croft, Director of Public Instruction, visited the College on the 24th March, and spent a considerable time in watching the apprentices at work in the shops, and in enquiring into details connected with practical instruction. Such visits from influential officers interested in the College are much to be desired.

Models.

No models were purchased during the year, but by special sanction the greater part of the model grant has been expended upon a lithographic press and upon some tools and appliances for the lathe purchased last year. Mr. F. J. E Spring, C.E., has most kindly presented the College with models of one abutment, one pier, and one girder of the Sher Shah bridge; these remain in the Principal's office, as there is no other place for them.

Conduct.

There is nothing special to report with reference to the conduct of students during the year; there has been no serious breach of discipline; but, on the other

hand, no marked signs of improvement are discernible. Young Bengal is peculiarly impatient of control, and strongly resents any interference with his liberty, consequently proper discipline cannot be maintained at this College, where the only boundary is a wire fence, beyond which boys may stray with impunity after dusk, in other words, it is not possible to confine students within bounds.

Athletics.

An annual subscription of Re. 1-8 per student being now compulsory, the Athletic Club is in a solvent state, and lawn-tennis, cricket, and football, especially the latter, flourish, and are played by all creeds and colours. Last cold season there were two Hindus in the cricket eleven, and they acquitted themselves well. This eleven was most unfortunate in losing the Harrison shield by one run only. Mr. Kuchler, in the absence of Mr. Slater, President of the Club, with great good nature, and with the expenditure of a very considerable amount of trouble, made all the preparation for, and most successfully carried out a day's athletic sports on March 15th. The events were eagerly contested by natives and Europeans, the prizes being pretty equally divided between them.

Health.

A report on the health of the College during the past year by the resident Medical Officer is annexed as Appendix A. From this it will be seen that there was a slight increase of sickness, the average daily number of students on the sick list, excluding those laid up by accidents, being 7·62 or, as the average daily attendance was 208, 3·66 per cent., against 3·57 per cent. per diem last year. At the end of March, influenza attacked the College, and spread amongst students and servants with such rapidity that on the 28th about 80 persons were down with the disease, consequently it was decided to close the College for three weeks. Students in health and invalids strong enough to travel departed at once, whilst the sick were detained till they recovered, or until friends arrived to remove them.

Workshops.

Senior apprentices are altogether employed in the shops. The other four apprentice classes attended shops daily from 8 A.M. to 11 A.M., except on Saturdays, when the hours were from 8 A.M. to 10 A.M. It has been arranged to commence shop work for the future at 7 A.M. during the hot season, thus allowing the boys to get away one hour earlier

Engineer-students, with the exception of the 4th-year class, attended shops daily, Saturdays excepted, from 1 to 3-30 P.M.

Mr. Bradshaw, Sub-Engineer, was transferred from Seebpore Shops in February last, and Rai Sarat Chundra Ghose Bahâdur, Honorary Assistant Engineer, formerly in charge of the Akra brick fields, is now responsible for the mechanical training of students and apprentices.

Volunteers.

The number of men in the Volunteer Corps on the 31st March was 36. Of these 7 were marksmen, 23 extra efficients, 6 efficients and 5 proficients. The figure of merit of the Corps was 142·6, against 137·48 last year

A rifle range is being constructed about half mile to the west of the Botanic Gardens. This will be a great convenience, as hitherto volunteer-students have been obliged to attend the range near Bally, East Indian Railway.

Library.

Fifty-six books were added to the Library last year. Of these 15 were presented and 41 purchased.

The total expenditure of the College during the year was Rs. 63,423, of which Rs. 54,086 were from grants from Provincial Funds and Rs. 9,337 from fees, against Rs. 62,467, Rs. 55,464, and Rs. 7,003, respectively, for the previous year, showing an increase in expenditure of Rs. 956, and also an increase of Rs. 2,334 in fees received. The above figures are exclusive of hostel expenditure and receipt, which are given in a separate report.

S. F. DOWNING,

The 25th April 1890. *Principal.*

E. D'S.—Reg. No. 10J—75—25 6-91